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Duration of Sperm Function in the Percid Fishes *Etheostoma lepidum* and *E. spectabile,* Associated with Sympatry of the Parental Populations

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CLARK HUBBS

ANIMALS have evolved many methods by which they prevent or reduce the frequency of hybridization. A large proportion of the studies on these isolation mechanisms concern terrestrial organisms. The isolation mechanisms reported show a great array of methods by which animals are protected against hybridization (Mayr, 1942; Dobzhansky, 1951). Isolation mechanisms are often divided into those that occur before gamete release thus conserving gametes, and those that occur after mating, which involve a wastage of gametes (Muller, 1942; Littlejohn, 1960). The failure of pollen-tube growth in interspecific crosses between certain higher plants (Stebbins, 1950) somewhat bridges the gap between the two major categories in that it occurs before fertilization, involving a wastage of at least one gamete. This gamete wastage is not likely to be of major importance, as pollen production is much greater than ovule production.

Most aquatic animals differ from terrestrial animals in that they require means of preventing chance meeting of gametes floating in the currents of the natural environment. In this regard they resemble higher plants, except that both gametes are involved. Lillie (1921) showed that eggs of sea urchins are more readily fertilized with homospecific sperm than heterospecific sperm. The eggs carry gynogamone II which agglutinizes foreign spermatozoans (Hoar, 1957). This operates to prevent fertilization and involves the wastage of one gamete. Again this is the paternal gamete, which is usually in great excess.

Gametic isolation might be expected to occur in fishes, but as yet has been documented only in lampreys (Montalenti, 1949). The absence of reports of this phenomenon may be due in part to the fact that most of the intensive work on isolation mechanisms of higher fishes involves poeciliids, which practice internal fertilization (Gordon's, 1957, discussion of isolating mechanisms is virtually limited to poeciliids) and thus in effect resemble terresterial animals in their development of isolating mechanisms. Its apparent absence or infrequence may in part account for the numerous known natural hybrids in fishes listed by C. L. Hubbs (1955). He stated, "Hybridization in the minnows has been attributed largely to the chance meeting of sperm and egg." A classic example is the high frequency of hybrids between *Notropis rubellus* and *N. cornutus.* The two species often spawn at the same time in the same stream. *N. rubellus* spawns in midwater and *N. cornutus* near the bottom (C. L. Hubbs and Brown, 1929). I suspect that the hybrids result from unfertilized *N. rubellus* eggs dropping into the cloud of *N. cornutus* sperm. An isolation mechanism to prevent such hybridization would thus involve already wasted eggs. Demonstration of a mechanism to prevent the production of hybrids from wasted gametes would document the strong selection against those individuals within a population which are more able to produce hybrids.

A previous report on this subject (C. Hubbs, 1957) showed a relationship between length of sperm function and frequency of natural hybridization. Additional unpublished data are in accord. This indicates that some of the reported natural hybridization may result from this circumstance rather than from the degree of phylogenetic relationship.

An indication of a differential fertilization between homospecific and heterospecific matings was noted by C. Hubbs and Drewry (1958), who obtained evidence of a preference for *Fundulus grandis* sperm over *F. similis* sperm by *F. grandis* eggs. Their data are inconsistent with my tentative hypothesis that the low natural hybridization frequency in marine fishes (C. L. Hubbs, 1955) might be due to short sperm function.

MATERIAL

Sperm of the darters, *Etheostoma lepidum* and *E. spectabile,* have been used to test their fertilizing ability against eggs of both species as well as against eggs of *Percina caprodes* and *Hadropterus scierus,* members of closely related genera. Most darters, and all reported here, breed in rapids of freshwater creeks and

rivers (Fahy, 1954; C. Hubbs and Strawn, 1957A; Winn, 1957, 1958A, 1958B). Currents here may sweep a gamete of either sex from the spawning pair and by chance it may meet a gamete from another spawning pair. Because many of the species spawn in the same riffle at the same time (C. Hubbs and Strawn, 1957B), the chance meeting of gametes is possible. The possibility of homospecific fertilization of these water-born gametes is not great, thus most of them are wasted gametes.

Other factors also serve to isolate the various species of darters; however, those that are most effective tend to prevent intentional crosses, rather than those that result from chance. Gamete incompatibility is not included among them as C. Hubbs and Strawn (1957C), Lindler (1958), and C. Hubbs (1959) reported on laboratory-produced hybrids that include all of the possible combinations included in this study. Seasonal isolation is also ineffective, for *E. lepidum* and *E. spectabile* breed in response to temperatures (Hubbs and Strawn, 1957A) that overlap widely. Mate recognition appears to be a major isolating mechanism. (Every time after a ripe pair of *E. lepidum* and *E. spectabile* had been placed together in an aquarium no fertilized eggs were noted, although both controls bred readily under the same conditions). Ecological isolation also appears to play a role, because in the Guadalupe River, where the two are sympatric, *E. lepidum* prefers riffles with much vegetation, whereas *E. spectabile* is most common in the absence of vegetation (C. Hubbs, Kuehne, and Ball, 1953). Where they are allopatric, the two species freely occupy both habitats. This, however, is not primarily a reproductive phenomenon, as the ecologic separation occurs at all seasons. Hybrid sterility undoubtedly fortifies these mechanisms, as C. Hubbs (1958A) reported that *E. spectabile* × *E. lepidum* hybrid males were sterile; whereas the females were fertile. Moreover, C. Hubbs and Strawn (1957B) reported that *E. spectabile* × *P. caprodes* hybrids were apparently sterile intersexes. Likewise, hybrids between *E. spectabile* and *H. scierus* and between *E. lepidum* and *H. scierus* or *P. caprodes* appear to be intersexes. The first *H. scierus* × *P. caprodes* hybrids reared in our laboratory are still immature.

E. lepidum is limited to the limestone headwaters of the Colorado, Guadalupe, and Nueces rivers in Texas. *E. spectabile* ranges from southern Michigan to central Texas, where it occurs in the limestone headwaters of the Brazos, Colorado, and Guadalupe rivers. It has never been noted in numerous collections from headwaters of the Nueces River, where no darters other than *E. lepidum* occur. *E. lepidum* is unknown in the Brazos System. Thereby, it is possible to determine whether the operation of a gametic isolation mechanism is related to whether the population of one species is allopatric, or sympatric, with other species with which they might produce hybrids.

The stocks of *E. spectabile* utilized were those collected from the Brazos, Colorado, and Guadalupe river systems. The stocks from the Brazos system, which are allopatric with *E. lepidum,* were compared with the others. The Brazos stocks came from the Lampassas River five miles south of Belton, from Salado Creek at Salado, and primarily, from the San Gabriel River at Georgetown. The Guadalupe and Colorado river stocks came from the Guadalupe River between Hunt and Ingram, from the San Saba River at Fort McKavett, from Barton Creek at Austin, from the San Marcos River near San Marcos, and, primarily, from the Colorado River at Austin.

Material of *E. lepidum* came from the Colorado, Guadalupe, and Nueces river system stocks. Those from the Nueces System, where *E. lepidum* is allopatric with *E. spectabile,* were compared with the others. The Nueces stocks came from the West Frio River at the mouth of Kent Creek, from the mouth of Kent Creek, from Montell Creek six miles northwest of Montell, from the East Nueces river at Barksdale and, primarily, from the East Nueces River, five miles south of Camp Wood. The Colorado and Guadalupe river stocks came from the South Guadalupe River nine miles west of Hunt, from the Gudalupe River between Hunt and Ingram, from the Colorado River at Austin, from Barton Creek at Austin, from the San Saba River at Fort McKavett, and from the South Concho River four miles south of Christoval.

Material of *H. scierus* came from San Marcos, Austin, and from various localities in eastern Texas.

Material of *P. caprodes* came from San Marcos, Austin, Georgetown, Fort McKavett, east Texas, and southeastern Oklahoma.

Geographic variation occurs among the various populations used. *H. scierus* from San Marcos has been placed in a separate subspecies (C. Hubbs, 1954) but eggs from both subspecies act similarly with *Etheostoma* sperm. The eggs of *P. caprodes* and *E. spectabile* vary in size in this area (C. Hubbs, 1958B). Oddly, the eggs of *E. spectabile* from

the Guadalupe River resemble those from the Brazos River much more closely than they resemble those from the Colorado River, but no correlation was found between egg size and longevity of sperm. *E. lepidum* has been shown to exhibit interpopulation variation (Strawn, 1955 and 1957), but the differences he reported are discordant with differences in the selection by eggs against foreign sperm. Eggs from the Nueces River are much larger than those from the other stream systems (C. Hubbs and Delco, Ms) and thus are in concordance with gametic isolation.

Methods

The duration of sperm function was studied by stripping about a pinhead of sperm from a male fish into an enamel rearing pan containing approximately one gallon of water. The male was dipped into the water vigorously so that resulting currents dispersed the semen. After an interval timed with a stopwatch, eggs were stripped into the same container. Because only two experiments were run at less than five seconds, the discussions are limited to longer time lapses. The number of eggs produced by the female and the number that developed pigmented eyes were recorded. Although the few fertilized eggs that die before the eyes become pigmented might adversely affect the resulting percentages, many other developing eggs are gynogenetic (Lindler, 1958; C. Hubbs, 1959; C. Hubbs and Drewry, 1960) and most of these die before eye pigmentation. All hybrids reared showed the normal effect of paternal chromatin. Moreover, all experiments were carried out under essentially the same conditions. Thus, the percentages of eggs that attain pigmented eyes approximates the percentage that are fertilized. To minimize the effects of temperature on sperm activity (Lindroth, 1947), all experiments were carried out at 15 ± 2°C.

Postfertilization techniques follow those described by Strawn and Hubbs (1956). The first experiments showed reduced survival with increased time lapse (C. Hubbs, 1957), which was thought to reflect another isolation mechanism. However, in recent experiments no difference has been noted in the survival of embryos fertilized by sperm exposed for various intervals. C. Hubbs, Littlejohn, and Littlejohn, 1960) showed that the low survival could be attributed to ammonia poisoning. Therefore, this indication of an additional isolation mechanism must be discounted.

Results

Duration of sperm function in *Etheostoma lepidum*

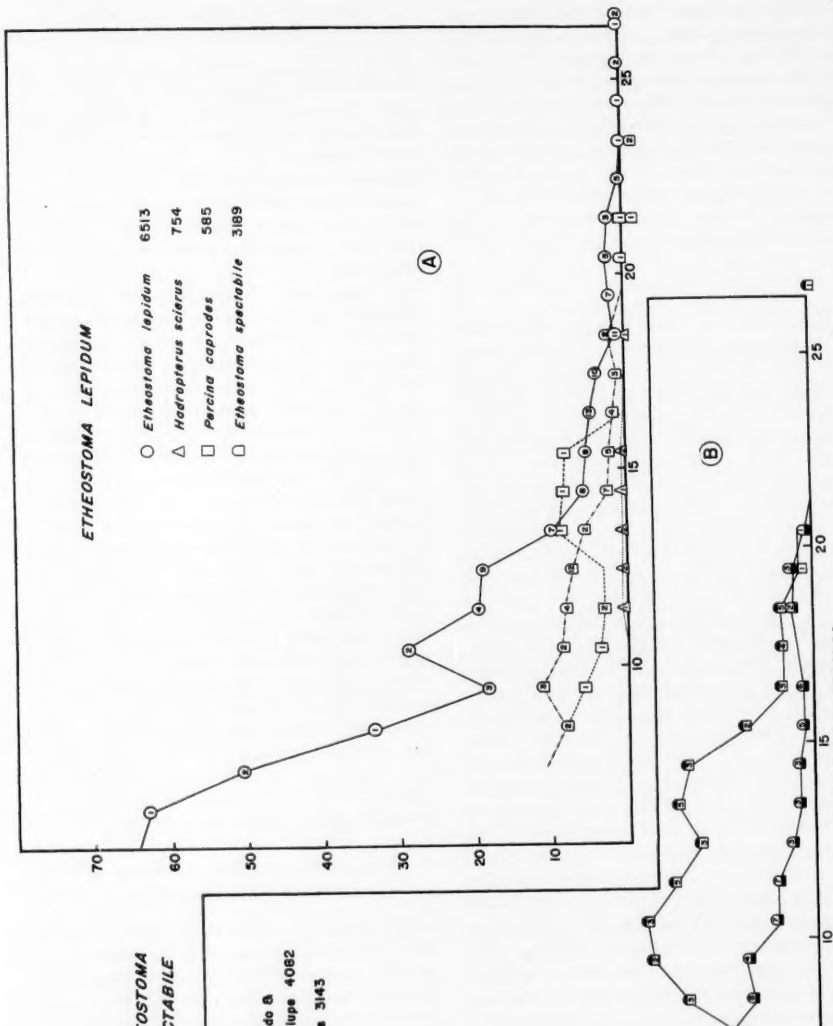
The percentage of *E. lepidum* eggs that are fertilized by *E. lepidum* sperm decreases markedly with increase in time of exposure, with cessation of sperm function after a delay of 20 to 25 seconds (Fig. 1A). The curve fluctuates somewhat but appears to be logarithmic. As this curve is based on the largest samples and fits a reasonable hypothesis, major deviations from this pattern are probably due to sampling error.

The duration of *E. lepidum* sperm function is notably decreased in heterospecific matings. *H. scierus* eggs have a very low fertilization percentage at all time lapses (the extremely low figures may be due in part to small sample size). *P. caprodes* eggs usually have a low fertilization percentage (the slight rise around 15 seconds is probably due to chance as it is based on a single, very successful experiment; the curve distinctly deviates from the expected logarithmic pattern, in part because of small sample size). *E. spectabile* eggs almost invariably have a low fertilization percentage (the only exception is at the time delay of 18 seconds, at which the values for *E. lepidum* are lower and those for *E. spectabile* are higher than for adjacent time delays).

Interpopulation variation may affect details of the curves; however, the differences between the various percentages are so great that the pattern would remain valid. Therefore, sperm of *E. lepidum* fertilizes eggs of *E. lepidum* better after time lapse than they fertilize eggs of three other species.

Duration of sperm function in *Etheostoma spectabile*

The duration of sperm function is considerably longer in *E. spectabile* from the Brazos System (allopatric to *E. lepidum*) than in *E. spectabile* from the Colorado and Guadalupe systems (sympatric with *E. lepidum*) (Fig. 1B). Except for the two ends of the curves, figures for allopatric males are higher than those for sympatric males. The slight overlap at 19 seconds is considered due to sample size as there is a peak in the curve for sympatric *E. spectabile* at that time lapse. Percentages for the allopatric stock between five and ten seconds time lapse are low and definitely deviate from a logarithmic curve. The experiments involving these time lapses were notably unsuccessful, probably because the



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females employed in six of the ten experiments had been obtained at the end of the spawning season. The eggs or sperm were also probably harmed by warm temperature at the collecting station or while being transported to Austin. If these questionable experiments were discarded, the curve would continue to rise to about 30 percent fertilization at six seconds time lapse. Percentages for the sympatric stocks may also have been affected somewhat adversely by the same circumstance, except that the last samples used had been obtained a week earlier in cooler weather, from spring water (cooler in May), and nearer the laboratory. If all late-season eggs had been excluded, the curves would not overlap. It is possible that the differences are due to the vigor of the sperm or to the activity of the egg. As the pattern of the two reciprocal crosses follows that of the paternal controls, sperm vigor is the reasonable hypothesis. Moreover, the sperm of the allopatric stock does much better when crossed with eggs of other species than does the sperm from sympatric males. Therefore, sperm of males from populations allopatric to their nearest relative is more vigorous than sperm from males of the same species from populations sympatric with their nearest relative.

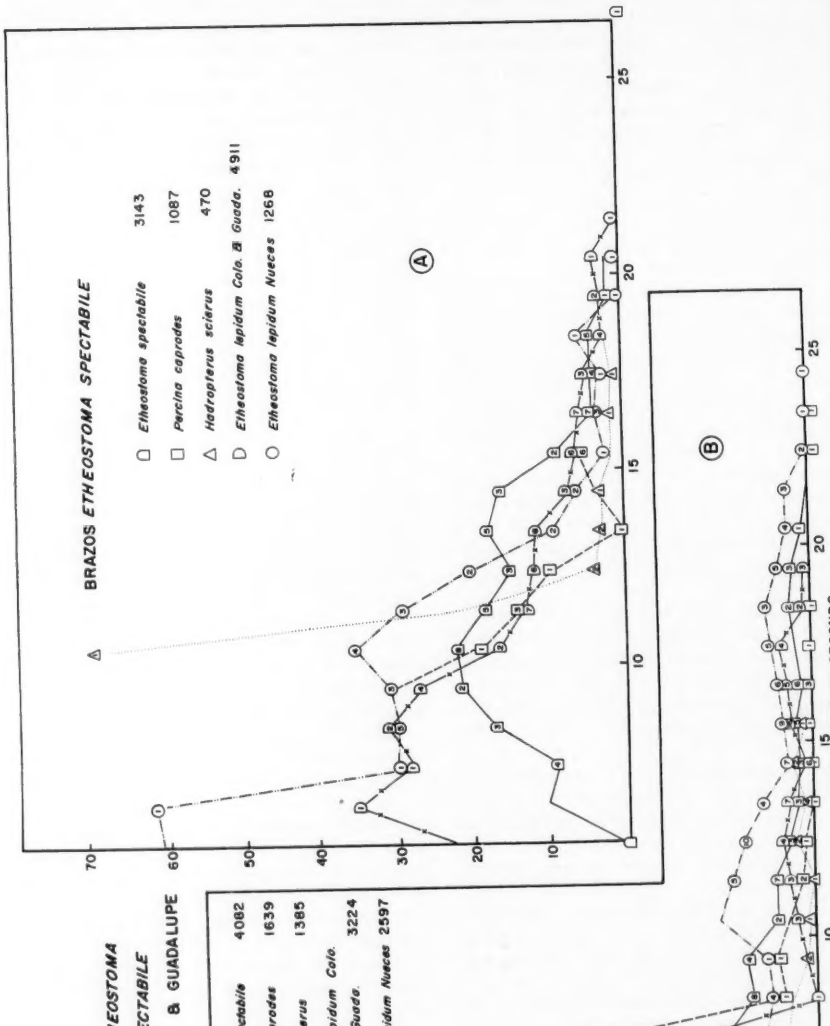
In general, sperm of *E. spectabile* from allopatric stocks fertilizes a larger percentage of *E. spectabile* eggs after a given time lapse than eggs from other species (Fig. 2A). This is most pronounced between ten and 15 seconds time lapse when the figures are most valid. The few high figures for *P. caprodes* and *H. scierus* eggs are undoubtedly due to sampling error, as the percentages fluctuate widely and often are extremely low. Eggs of *E. lepidum* have been separated into two categories: those from the Colorado and Guadalupe river systems, where the species is sympatric with *E. spectabile*, and those from the Nueces River System, where *E. lepidum* is allopatric with *E. spectabile*. In general the figures for the eggs of the sympatric stock of *E. lepidum* follow the pattern of those for *P. caprodes* and *H. scierus*. The fertilization percentages rarely equal that of *E. spectabile* controls except at times less than ten seconds; and, if the dubious *E. spectabile* controls were discarded, this exception would be eliminated. Eggs of the allopatric stock of *E. lepidum* appear to have higher fertilization percentages, notably so in the 10–12 second time lapse, for which the sample size is largest. The 13–15 second figures are based largely on late-season eggs that may have been adversely affected by warm temperature. Not only do eggs from the allopatric stock of *E. lepidum* have a higher fertilization percentage than their sympatric counterparts, but also they may have a higher fertilization percentage than that of the *E. spectabile* eggs.

Fertilization percentages for the sperm of sympatric stocks of *E. spectabile* are comparable but at lower figures (Fig. 2B). *H. scierus* eggs do far poorer than *E. spectabile* eggs. The extreme difference may be due in part to the use of late-season eggs that were exposed to warm temperature. The figures for the eggs of sympatric stocks of *E. lepidum* and eggs of *P. caprodes* are more or less equal to those for *E. spectabile* eggs. This may be due to the difficulty of obtaining a difference at such a low fertilization percentage. The fertilization percentages for eggs of allopatric stocks of *E. lepidum* are high. This is most notable in experiments involving time lapses greater than ten seconds, in which the eggs of allopatric *E. lepidum* invariably show the highest fertilization. If the data for all late-season eggs are discounted, the figures for delays of less than 10 seconds would also be invariably above those of the controls.

Therefore, eggs can vary in their capacity for fertilization. This may be due to an increased and non-selective attraction for sperm by the eggs from allopatric stocks, such as is produced in sea urchin eggs by gynogamone I, or to a loss of the capacity to agglutinate foreign sperm, such as results from the action of gynogamone II. The question of whether either factor is acting here remains unsolved, but does not affect the basic tenet that eggs of allopatric populations are more readily fertilized than are eggs of sympatric populations.

The eggs of allopatric stocks of *E. lepidum* have larger diameters than do those of the sympatric stocks. Such size differences may ac-

Fig. 1.—Percentages of darter eggs that were fertilized by male sperm which had been exposed to aged Austin (Texas) tap-water for timed intervals: A. several species of darter eggs fertilized by *Etheostoma lepidum* sperm; and B. *Etheostoma spectabile* eggs fertilized by sperm of male *E. spectabile* from the Brazos River system and from the Colorado or Guadalupe River system. All experiments within a given second delay were pooled. The percentages were then obtained by rounding the figures with those of the adjacent seconds delay. The numbers within the symbols are the number of experiments at each second delay. The numbers in the keys are the total number of eggs used.



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count for the absence of sperm selection by the large eggs. This possibility is contradicted by the effective selection by *H. scierus* eggs which are even larger. However, even if increased egg size decreases its sperm selection, the relationship with allopatry remains unchanged. Allopatry might permit the egg size to increase because of the absence of selection against size which would be associated with hybrid production.

Discussion

In general the sperm of *E. spectabile* and of *E. lepidum* is more capable of fertilizing homospecific eggs than heterospecific eggs, after time lapse. As this isolation mechanism is not effective against intentional hybridizing, it must work against accidental hybridization. Accidental hybridization would result from the chance meeting of gametes swept away from the mating pairs by the strong currents in the spawning environment. Thus, some darters have evolved an isolation mechanism against the fertilization of gametes essentially already wasted. The evolution of such an isolation mechanism shows the strong selection against individuals within a population that are capable of producing hybrids. This concept is consistent with the high incidence of natural hybridization in the more primitive genera of the subfamily, and the rarity of interspecific crossing in the more specialized darters (C. L. Hubbs, 1955).

Populations allopatric to their near relatives appear to have developed methods of increasing their fertilization potential in two ways. The populations of *E. spectabile* from the Brazos System are allopatric to species with which they can exchange genes but are sympatric with species with which they can hybridize to produce sterile offspring. These populations have an increased fertilization potential attributable to increased sperm vigor. Such increased sperm vigor would tend to produce more hybrids but only at the expense of foreign eggs. As these eggs are isolated against *E. spectabile* sperm the increased hybridization potential would be minimal. The populations of *E. lepidum* from the Nueces System are allopatric to all species with which they can produce viable hybrids. These populations appear to have increased the fertilization potential by eliminating the differential selection against heterospecific sperm. These responses to allopatry recall the similar pattern of geographic distribution of isolating mechanisms in *Microhyla* (Blair, 1955) and support the hypothesis of reinforcement of isolating mechanisms of Dobzhansky (1940, 1951). The absence of a selective factor in the eggs from allopatric stocks may actually be the loss of the reinforcing mechanism, thus "dereinforcement."

The sperm of *E. spectabile* actually fertilizes a larger percentage of allopatric *E. lepidum* eggs than those of its own species after time lapse. It is apparent, therefore, that in isolating against hybridization, the eggs of *E. spectabile* have become somewhat isolated against sperm of *E. spectabile*. Carried to the extreme, this might result in extermination of the species by a reduction of offspring. A mechanism to prevent accidental gamete fusion might have a selective advantage. Most fishes have promiscuous mating habits. The dominant male usually fathers a large fraction of the young within a hierachy (C. Hubbs and Strawn, 1957A; McAlister, 1958). Any mechanism to increase the number of young fathered by the dominant male might increase the fitness of that population.

Conclusions

1. Accidental fertilization by gametes swept from the spawning pairs is possible in freshwater fishes.
2. Darter eggs appear to have a selective factor that reduces the possibility of hybrids resulting from such current-swept gametes.
3. A darter population allopatric to species with which the individuals can exchange genes has sperm which maintains its fertilization capacities longer.
4. A darter population allopatric to species with which the individuals can hybridize has eggs which have lost the selective factor against foreign sperm.

Acknowledgments

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Fig. 2.—Percentages of darter eggs that were fertilized by male sperm which had been exposed to aged Austin tap-water for timed intervals: A. various kinds of darters fertilized by sperm from the Brazos River population of *Etheostoma spectabile*; and B. various kinds of darters fertilized by sperm from Colorado or Guadalupe River populations of *E. spectabile*. Other circumstances are as described in Fig. 1.

Mr. C. L. Secor and Mrs. Ford Boulware have freely given permission to collect from their ranches. Notable among the many individuals who have assisted in collecting stocks are: R. Beyers, E. A. Delco, Jr., G. E. Drewry, M. A. Drewry, W. F. Hettler, C. L. Hubbs, J. C. Hubbs, L. E. Hubbs, R. K. Hunter, F. C. Johnson, M. V. Johnson, R. S. Jones, M. J. Littlejohn, B. Maguire, Jr., T. C. Michaud, R. E. Moore, C. D. Riggs, and K. Strawn. In addition I am indebted to my many colleagues with whom I have discussed this problem. Carl L. Hubbs has read and criticized the manuscript.

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Growth of the Common Eastern Madtom, *Noturus insignis* in Central Pennsylvania[1]

JAMES P. CLUGSTON[2] AND EDWIN L. COOPER

THE common eastern madtom, *Noturus insignis* (Richardson), is a member of the catfish family (Ictaluridae) found abundantly in many streams east of the Allegheny Mountains, and from the tributaries of Lake Ontario southward to Georgia (Taylor, 1955). However, since it is a nocturnal fish and rarely reaches six inches in length, very few people know of its existence. Those who have come in contact with it, either catching it on a worm while fishing for another species of fish or using it for bass bait, have learned to respect it for the painful sting it can render with its dorsal and pectoral spines.

Many phases of the life history of *Noturus insignis* have been described by Fowler (1917), and Bowman (1932, 1936). However, their work contains little information on the rate of growth and periodicity of growth of this species. Bowman (1932) did plot a length-frequency curve using 186 specimens that fell into three well-defined size-groups. These he assumed represented fish of four months, 16 months, and 32 months of age. From available reports his apparently was the only attempt to determine the age of this species.

During the last 15 years many other catfishes have been aged by the use of various bony structures (Kalman, 1943; Hooper, 1949; Lewis, 1949; and Hall and Jenkins, 1952). These studies have been based on observations that the catfishes show seasonal changes in the growth of the bones. Several studies have confirmed the accuracy of these observations through the use of known-age material (Appelget and Smith, 1951; Sneed, 1951; and Marzolf, 1955).

In the present paper, the year marks observed on the pectoral spines were used to determine the age of the common eastern madtom. The results of studies of longevity, size at maturity, and seasonal growth based on these age determinations tend to confirm the accuracy of this method of age determination.

PROCEDURE

During the study period, which lasted from November 1957 to November 1958, approximately 950 madtoms were collected from the Bald Eagle Creek in Centre County, Pennsylvania. These were taken in seven collections of between 100 and 150 fish. Collections for only young-of-the-year were made in September and October of 1958.

Collections were made by using a Homelite 230-volt, 2500-watt, direct-current electric shocker. A 220-volt, 500-watt, 400-cycle, alternating-current generator was also tried, but was unsatisfactory since it would not attract the madtoms to the electrode from underneath the rocks in the stream bottom.

The specimens were transported alive to the laboratory and anesthetized with tricaine methanesulfonate (MS 222). The left pectoral spine was removed by the method described by Sneed (1951).

After drying, each spine was scraped clean with a small scalpel and mounted on a cellulose-acetate slide with Duco-Cement. The mounted spines were allowed to dry about 24 hours before sections were made. It was found if sections were made less than ten hours after the spines were mounted, the cement would cling to the saw blade, making it necessary to clean the blade after each sectioning. On the other hand, if they were not sectioned for a number of days the cement became too hard and the spine was usually shattered during sectioning. Sections were made by a method similar to that devised by Leonard and Sneed (1951), except that the cutting blade consisted of two, ¾-inch, circular saw blades separated by a washer 0.5 mm. thick. Therefore, with one cut, a complete section was made which was always the same thickness.

After the cut was made, the cement at the bottom of the spine held the section to the slide, and by bending the slide slightly in the area of the cut, the section could be easily removed with a pair of forceps. It was necessary to change the blades after cutting 100 sections because they became dull and began to crack the sections. The sections were taken, as described by Sneed (1951), at the distal end of the deep groove at the base of the spine to make sure that all of the annuli could be seen.

The sections were placed on a glass slide, cleared with alcohol or glycerine, and observed by means of transmitted light with a binocular microscope at a magnification of 40

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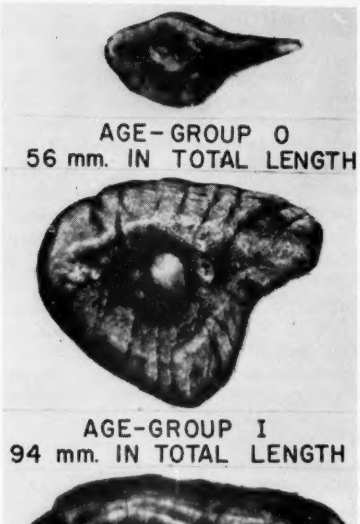

Fig. 1.—Cross sections of pectoral spines of the common eastern madtom, *Noturus insignis*, collected November 23, 1957. Magnification about 70 ×.

diameters. In viewing the sections, wide dark zones were seen to alternate with narrow clear zones. The dark zones represent summer growth and the clear zones, the winter growth. The clear zones are considered to be the year marks or annuli (Fig. 1).

In the present work with *Noturus insignis* the total length was considered the most desirable and accurate to use, and is used in the text unless indicated otherwise. Since the tails are not forked and most of them were not frayed or mutilated, there was little question as to length determination. However, since in the literature many of the specimens collected have been reported in standard length, the regression of standard length on total length was calculated. Using a sample of 250 fish, representing the entire range in size appearing in the collections (Table I), the relationship between standard length and total length was determined to be as follows:

$$Y = -0.65 + 0.851\ X, \text{ where}$$

Y equals standard length in mm. and X equals total length in mm. The correlation coefficient between Y and X based on the sample of 250 fish was found to be +0.99.

Growth in Length

The age was determined for 776 madtoms collected between November 1957 and November 1958. Most of the fish collected were in age-groups I, II, and III with only a few in age-groups O and IV (Table II). The oldest fish collected was four years old.

Few young fish were obtained in the collections. However, electrofishing devices are

Table I

Comparison of Total Length, Standard Length, and Weight of 250 Common Eastern Madtoms, *Noturus insignis*, Collected Throughout the Year.

Total Length in mm.	Number of Individuals	Mean Total Length in Millimeters	Mean Standard Length in Millimeters	Mean Weight in Grams
16–20	9	19.2	15.9	0.1
21–25	12	22.0	18.0	0.2
26–30	5	29.0	24.0	0.4
31–35	7	33.3	27.8	0.5
36–40	5	37.0	30.6	0.6
41–45	6	43.3	36.3	0.9
46–50				
51–55				
56–60				
61–65	6	63.3	54.0	2.6
66–70	10	68.7	57.8	3.3
71–75	21	73.1	62.0	3.9
76–80	9	77.5	65.8	4.6
81–85	9	82.7	69.3	6.2
86–90	8	87.4	73.1	7.2
91–95	19	92.5	78.0	8.5
96–100	17	98.1	82.4	10.0
101–105	12	102.2	85.3	11.0
106–110	12	108.4	91.1	13.2
111–115	18	113.1	94.8	15.1
116–120	11	117.7	99.3	17.7
121–125	10	123.1	104.1	21.1
126–130	13	127.4	107.8	22.5
131–135	11	133.4	112.0	25.0
136–140	8	136.5	115.3	27.3
141–145	8	143.4	121.6	33.8
146–150	4	147.0	126.0	39.7

known to be more efficient in capturing larger fish (Schuck, 1943) and therefore the age-composition of the collections cannot be considered to accurately depict the structure of the population.

The first young-of-the-year were collected on July 13 and averaged 20.4 mm. long. This agrees with the observations by Bowman (1936) that the madtom spawns late in June. At 16 days of age his madtoms averaged 21 mm. long. Further indications of the time of spawning were the observations that many females collected on June 30 and almost all those on July 13 were spent. All females had spawned by the July 30 collection.

The largest fish collected were 158 mm. long. There were five of these and they were taken in three different collections.

During the first two years the annual increments of growth in length averaged about 45 mm., and during their third and fourth years of life the increments decrease to about 20 mm. (Fig. 2).

Most of the annual increment in growth occurs during a relatively short period; from June to September. There is some indication that yearling fish start growing somewhat earlier than older fish.

Sexual Maturity

Sexual maturity was determined by gross examination of the sex organs; no histological study was made. Mature females had large, orange-colored eggs approximately 4 mm. in diameter (Fig. 3, A). These were first observed when the fish were in the third summer of life or at 24 months of age.

The testes of the males had long finger-like projections which are characteristic of many catfishes (Fig. 3, B). These finger-like projections begin to develop in the young-of-the-year (Fig. 4, B). During their second summer the testes are somewhat smaller than those of the older fish but are very similar in appearance. Most males appear to be mature in their third summer, but judging by the whitish color of the mature testes, some males may mature during their second summer or a year before the females.

Sex Ratio

The sex was determined by dissection and observing the gonads. No external sex character was found reliable for differentiating the two sexes, other than the swollen abdomens of some ripe females. The sex of young-of-the-year fish could be determined internally at a size as small as 32 mm., but since it was impossible to determine the sex of all young-of-the-year fish in the collections, this age group was not included in the analysis of the sex ratio (Table III).

Although the total of all the collections would indicate that there are more females present than males in this madtom population, there is good evidence that some of the collections are biased. Three collections (totals for May 25, June 30, and July 13) have a significant deviation from the expected 50:50 sex ratio on the basis of a Chi Square test. These are followed however by collections which are close to the expected ratio.

Table II

Age-Groups of the Common Eastern Madtom for Different Times of the Year.

Under each date and age-group are recorded mean total lengths of the fish in millimeters, the standard error of the mean, and the number of fish in the sample, respectively. The collection made in November 1957 is placed at the end of the table in order that growth throughout the year may be more easily visualized.

Date 1958	Age-Groups				
	0	I	II	III	IV
April 26		45.2	95.3	116.8	133.6
		1.3	2.0	2.7	1.7
		(17)	(29)	(21)	(5)
May 25		42.5	98.6	118.1	136.5
		2.5	1.7	2.0	3.2
		(2)	(28)	(20)	(13)
June 30		64.1	98.3	112.7	135.9
		1.0	0.8	1.4	1.6
		(43)	(44)	(25)	(8)
July 13	20.4	67.2	98.1	111.8	125.3
	0.2	0.8	1.1	1.3	3.0
	(25)	(49)	(32)	(13)	(3)
July 30	25.5	71.4	99.1	114.1	130.1
	0.3	1.2	0.8	1.0	1.7
	(6)	(25)	(37)	(38)	(9)
Aug. 27	34.2	81.3	112.2	132.3	138.0
	0.9	0.9	1.1	2.3	5.0
	(13)	(44)	(81)	(16)	(2)
Sept. 17	42.5				
	1.1				
	(12)				
Oct. 19	45.9				
	1.5				
	(9)				
1957	52.6	89.4	114.9	133.8	
Nov. 23	3.6	1.7	1.8	2.2	
	(4)	(35)	(44)	(12)	

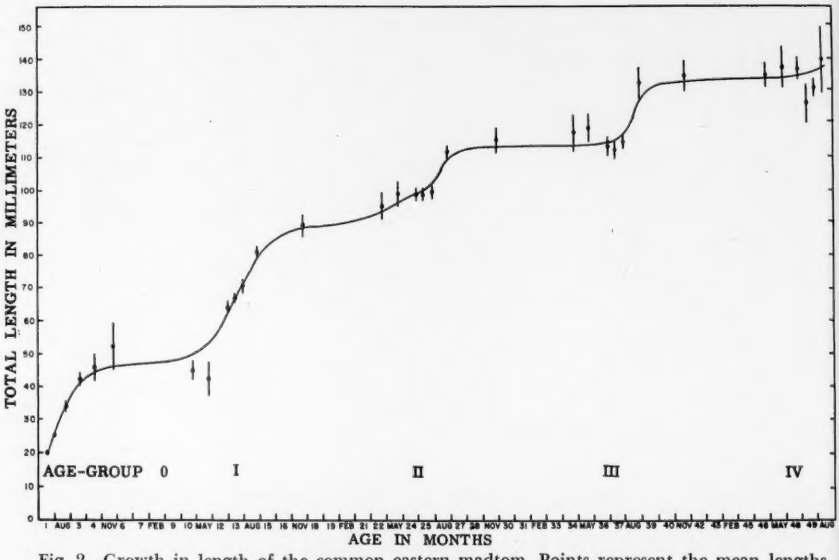

Fig. 2.—Growth in length of the common eastern madtom. Points represent the mean lengths and the vertical lines represent ±2 standard errors of the means. Line fitted by inspection.

A. FEMALE COLLECTED JULY 13, 1958. 122 mm. IN TOTAL LENGTH. (107 EGGS)

B. MALE COLLECTED MAY 25, 1958. 150 mm. IN TOTAL LENGTH.

Fig. 3.—Gonads of the mature common eastern madtom. A. Female collected July 13, 1958, 122 mm. in total length, contained 107 eggs in ovary. B. Male collected May 25, 1958, 150 mm. in total length, showing testes.

This extreme deviation from the expected 50:50 ratio occurs during the period of spawning and only in those groups which are sexually mature (age-groups II, III, and IV). If death of the males occurred after spawning, the high percentage of females should persist in the older age groups. However, after the spawning season, the sex ratio of the collections reverts to 50:50. It thus appears that the collections containing a large percentage of females are not biased due to differential mortality of the sexes.

Since differential mortality of the sexes was not observed, it is difficult to explain why so few male madtoms were captured during May, June and July. It has been reported (Fowler, 1917; Bowman, 1932) that the males guard the nests and young at this time; this change in behavior could affect the catchability of the fish. Or, the electrofishing may not have been sufficiently random over the entire stream area to find the males during this period if spawning behavior caused a change in distribution of the male population.

Length-Weight Relationship

The relationship between length and weight of the madtom was determined from a sample of 250 fish (Table I). This sample was stratified as to date of collection (Table II) and included the entire size range reported for the species. Fish were measured to the

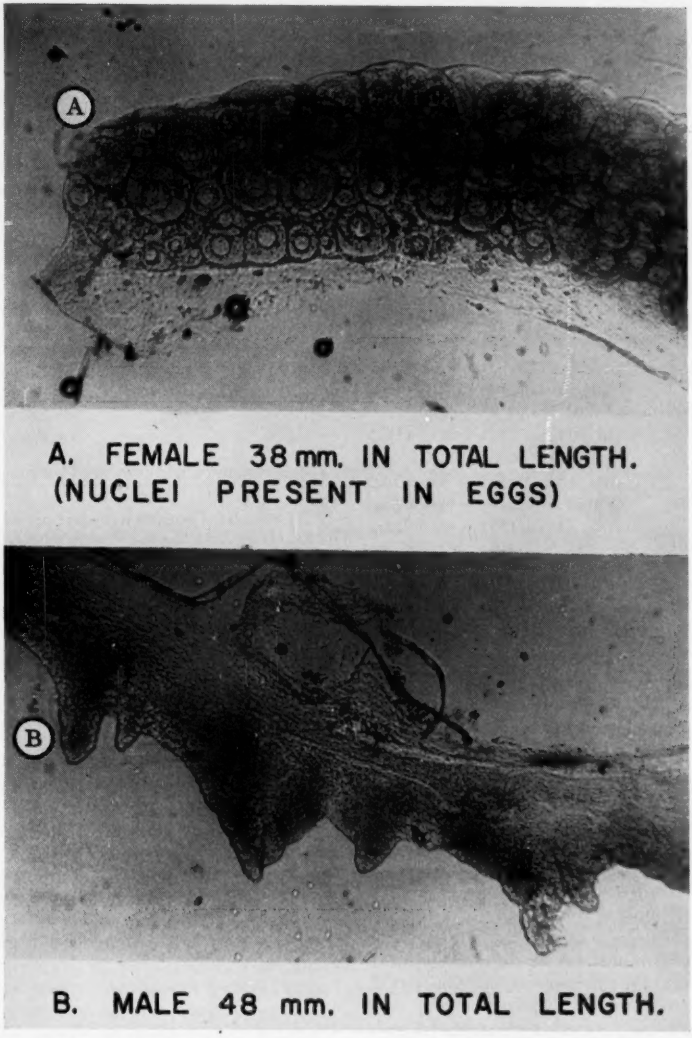

Fig. 4.—Gonads of young-of-the-year common eastern madtoms, collected October 19, 1958. Magnification about 70 ×. A. Female 38 mm. in total length (nuclei present in eggs). B. Male 48 mm. in total length.

nearest millimeter and weighted to the nearest 0.1 gram.

The length-weight equation for the common eastern madtom, solved by the method of least squares, is as follows:

$\log W = -4.748 + 2.89 \log L$, where

W equals weight in grams, and L equals total length in millimeters. These data were used to compute the expected weights of fish at different sizes in comparing growth at different seasons of the year.

Periodicity of Growth in Weight

For the common eastern madtom there is a rapid increase in length the first two summers of life and thereafter the majority of its growth appears to be confined to the late summer and fall months (Fig. 2). However,

TABLE III

SEX RATIO OF THE COMMON EASTERN MADTOM BY AGE-GROUPS FOR DIFFERENT TIMES OF THE YEAR.

Numbers in parentheses represent the number of fish in each sample. A single asterisk beside the percentage indicated a deviation from an expected 50:50 ratio significant at the 95 per cent level. Two asterisks indicates significance at the 99 per cent level.

Date of Collection	Percentage Female for Age-Groups				
	I	II	III	IV	Total
April 26, 1958		57.6 (26)	47.6 (21)	60.0 (5)	53.8 (52)
May 25, 1958		86.9** (23)	47.3 (19)	66.6 (9)	68.6** (51)
June 30, 1958	63.3 (30)	62.2 (43)	83.3** (30)	85.7 (7)	70.9** (110)
July 13, 1959	51.7 (29)	93.7** (32)	90.0* (10)	100.0 (3)	77.0** (74)
July 30, 1959	48.0 (25)	62.5 (32)	40.5 (37)	44.4 (9)	49.5 (103)
Aug. 27, 1959	59.2 (27)	55.8 (43)	37.5 (8)	50.0 (2)	55.0 (80)
Nov. 23, 1957	65.2 (23)	40.0 (25)	44.4 (9)		50.9 (57)

the periodicity of growth during a year or during the life of the fish may be seen more clearly by calculating the specific growth rate in weight as suggested by Brown (1957).

$$G = \frac{\log_e Y_T - \log_e Y_t}{T - t} \text{ times 100, where}$$

G is equal to specific growth rate expressed as percent per unit time. Y_T and Y_t are the weights recorded at times T and t, with T being later than t.

Because of the random variation of the average lengths of the collections taken at different times, for purposes of calculating specific growth rate the average weights were computed from the smoothed curve of Figure 2 (Table IV). Because these calculated weights are based on an average length-weight relationship of all seasons, only changes in weight associated with an increase in length can be detected with the present data. No studies of change in condition of the madtom were made. It is likely therefore that variations of greater magnitude occur in the specific growth rate than those shown in Figure 5. Short periods of negative growth might actually occur during the long periods of apparent zero specific growth rate.

For many animals, the specific growth rate is highest early in life and decreases with increasing age (Minot, 1891; Brown, 1957). This is true with the madtom, but also a very pronounced increase in specific growth rate can be seen in the summer following a very low rate for the winter months. Before sexual maturity is reached in both sexes (age-groups O and I), there is a very high specific growth rate during all the summer months. After sexual maturity is reached the majority of the growth occurs in the warm months after spawning. This might indicate that the majority of the food used by mature fish up to the time of spawning was used for egg and sperm production, and after spawning it was utilized for body growth. Some support for this idea suggested by Brown (1957) lies in the observa-

TABLE IV

SPECIFIC GROWTH RATE OF THE COMMON EASTERN MADTOM.

The calculated weights were determined by mean lengths (Fig. 2) at the end of each month. The time intervals ($T - t$) are based on the number of days in each month except for the first interval which is 18 days.

Age in Months	Total Length in mm.	Calculated Weight In Grams	Specific Growth Rate	Age in Months	Total Length in mm.	Calculated Weight in Grams	Specific Growth Rate
0	20.0	0.1	—	26	110.0	14.1	0.63
July	25.2	0.2	3.86	27	112.0	15.0	0.52
2	36.5	0.5	2.30	28	113.0	15.2	0.04
3	42.5	0.9	1.90	29	113.0	15.2	0.00
4	45.0	1.0	0.35	30	113.0	15.2	0.00
5	46.2	1.2	0.59	Jan	113.0	15.2	0.00
6	46.5	1.2	0.00	32	113.0	15.2	0.00
Jan	47.0	1.3	0.26	33	113.0	15.2	0.00
8	47.5	1.3	0.00	34	113.5	15.3	0.02
9	48.2	1.4	0.26	35	113.5	15.3	0.00
10	50.5	1.5	0.22	36	114.0	15.5	0.04
11	53.5	1.7	0.41	July	116.5	16.6	0.14
12	61.5	2.7	1.46	38	127.0	21.4	0.90
July	70.5	4.0	1.13	39	131.5	23.5	0.30
14	79.5	5.6	1.14	40	132.0	24.1	0.08
15	84.5	6.6	0.47	41	132.5	24.5	0.05
16	87.0	7.2	0.29	42	132.7	24.6	0.01
17	88.2	7.5	0.13	Jan	132.7	24.6	0.00
18	88.7	7.6	0.04	44	133.0	24.7	0.01
Jan	89.2	7.7	0.04	45	133.0	24.7	0.00
20	90.5	7.8	0.04	46	133.2	24.8	0.01
21	92.0	8.5	0.31	47	133.5	25.0	0.03
22	94.0	9.1	0.22	48	134.0	25.5	0.06
23	96.5	9.8	0.25	July	135.0	26.0	0.06
24	99.0	10.6	0.25	50	136.0	26.5	0.06
July	102.7	11.6	0.30				

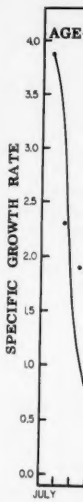

FIG. 5.- fitted by

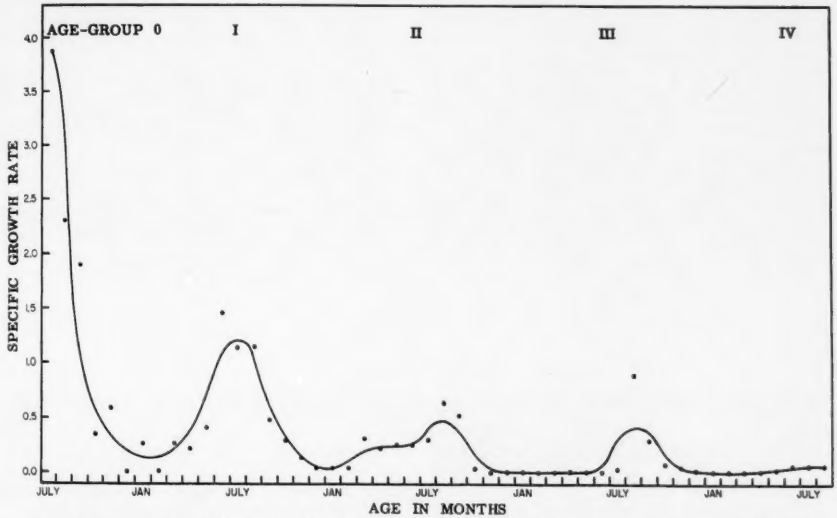

FIG. 5.—Seasonal variation in specific growth rate in weight of the common eastern madtom. Line fitted by a moving average of threes.

tion that beginning with the July 13 collection and continuing to the end of the study, a noticeable quantity of fat was observed in the body cavities of both sexes that was not present prior to July 13.

SUMMARY

The age was determined for 776 madtoms collected during the period from November 1957 to November 1958 by observing the growth pattern changes on the cross sections of their pectoral spines. Most of the fish collected were in age-groups I, II, and III with only a few in age-groups O and IV.

For the first two years the annual increments of growth in length averaged about 45 mm.; during their third and fourth years of life the increments decreased to about 20 mm. Most of the annual increment in growth occurred during a relatively short period: from June to September.

The maximum specific growth rate in weight of the madtom is high early in life, about 3.8 percent per day, and decreases with increasing age to approximately 0.5 percent per day. A very pronounced increase in specific growth rate occurs in the summer, following a very low rate for the winter months. Before sexual maturity is reached for both sexes, the specific growth rate is high during all the summer months. After sexual maturity is reached, the majority of the growth occurs after spawning in the months of July, August, and September.

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Chromosome Morphology in Lake Trout *Salvelinus namaycush*

RICHARD W. WAHL

THREE salmonids, the lake trout (*Salvelinus namaycush*), the arctic charr (*S. alpinus*), and the brook trout (*S. fontinalis*), have had a confusing taxonomic past. Recently, however, they have been shown by Morton and Miller (1954) to intergrade morphologically and have been placed by them in the same genus although Vladykov (1954) still prefers placement of lake trout in a separate genus, *Cristovomer*.

Genetical and cytological studies, which are frequently helpful to taxonomists, have been conducted on these three salmonids. Svardson (1945) has made a detailed study of chromosomes of the brook trout and arctic charr. Wright (1956) counted chromosomes in lake trout but did not study details of morphology. It seems worthwhile to present here information regarding chromosome morphology and number in lake trout and to compare this information with Svardson's (1945) descriptions of brook trout and arctic charr chromosomes.

MATERIALS AND METHODS

Lake trout eggs collected in October, 1956, from fish netted in Cayuga Lake, at Ithaca, New York, were incubated at the Cornell Experimental Fish Hatchery. Two- and three-day-old embryos were fixed in acetocarmine following the techniques of Svardson (1945) and Wright (1955). Temporary preparations, stained with aceto-carmine containing iron and smeared under a #0 or #1 cover slip, were examined at a magnification of 1450 diameters. Two-day-old embryos proved to have the greatest number of suitable divisions. Camera-lucida drawings of pro- and mid-metaphase chromosomes are shown in Figure 1.

KARYOTYPES

Lake trout and brook trout have the same number of chromosomes (2N = 84) but differ in chromosome morphology more than do the lake trout and arctic charr. The latter has 80 chromosomes.

It can be seen from Figure 2 that the chromosomes of the brook trout are fairly uniform in size whereas those of lake trout and arctic charr vary greatly from long V-shaped to short rod-shaped. The lake trout has one very long rod-shaped pair which was noted also by Wright (1956). All three species have eight V-shaped chromosomes assuming that the kinetochore (centromere) is positioned at the apex of the angle formed by the chromosome at metaphase and anaphase. Each species has one pair of chromosomes with a satellite at the end of a very long constriction. Svardson (1945) reports that this constriction is longer in the brook trout than in the arctic charr. The constriction varies considerably in the lake trout; it is very long at pro-metaphase (as in the brook trout) but is short at mid-metaphase (shorter than in the arctic charr). This long constriction has not been reported among the chromosomes of any of the other salmonids that have been examined although the smelt (*Osmerus mordax*) is reported by Svardson (1945) to have a similar, though much smaller, constriction on a rod-shaped pair. Like other salmonids, numerous constrictions are found in lake trout chromosomes

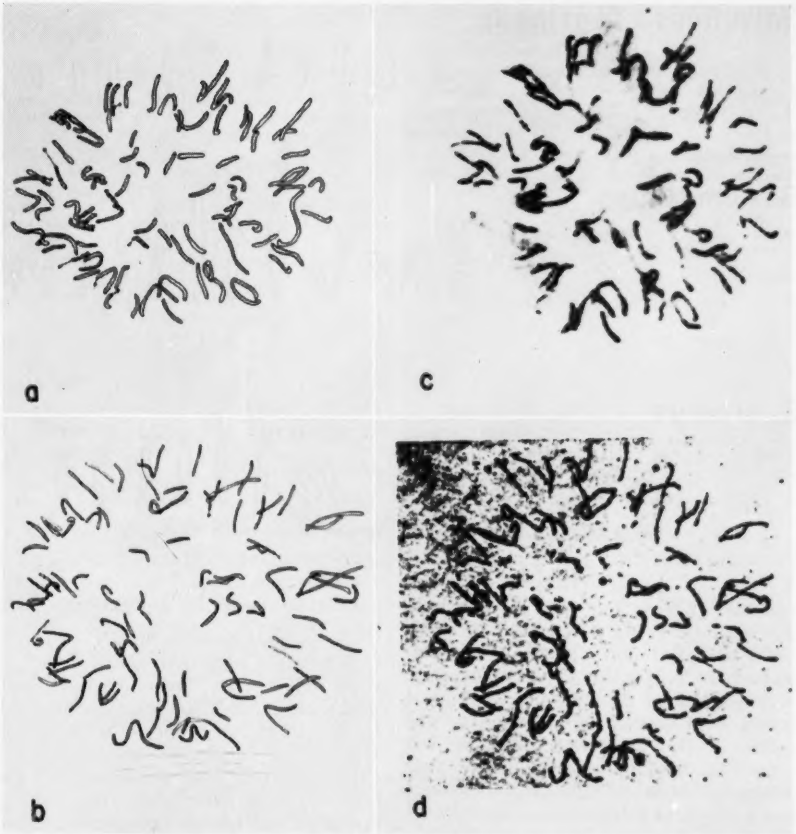

Fig. 1.—Drawings (a & b) and microphotos (c & d) of mid-metaphase and pro-metaphase chromosomes respectively of lake trout, *Salvelinus namaycush*.

at pro-metaphase but these usually disappear by anaphase.

Hybridization Experiments

Hybridization experiments carried out in Canada, Sweden and the United States have involved nearly all possible combinations among Atlantic (and landlocked) salmon (*Salmo salar*), rainbow trout (*Salmo gairdneri*), brown trout (*Salmo trutta*, three forms) brook trout, lake trout and arctic charr. Of these combinations none have been as successful as those among the three chars (arctic charr, brook trout, and lake trout).

Hybrids and backcross hybrids of lake × brook trout have been produced with relative ease (Bean, 1889; Stenton, 1952; Wright, 1955; Buss and Wright, 1956). Buss and Wright (1956) report that the second backcross hybrid (7/8 brook trout, 1/8 lake trout) averaged 80% survival of fry to resorption of the yolk sac stage, whereas pure brook trout average 67% survival at that same hatchery. Apparently, in this instance, hybridization and subsequent selection has produced heterosis (hybrid vigor).

Of the experimental crosses made at the station in Drottningholm, Sweden, among Atlantic salmon, brown trout, rainbow trout, brook trout, and arctic charr (Alm, 1954), only the arctic charr × brook trout hybrids display characters worthy of recommending them for rearing in ponds and releasing in lakes. Alm (1954) reports that arctic charr × brook trout hybrids are hardier in ponds than the arctic charr and are longer lived than the brook

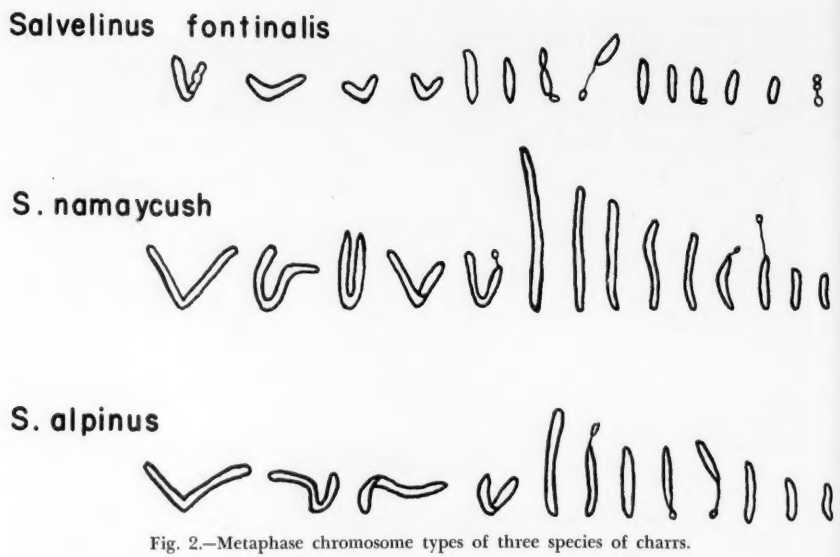

Fig. 2.—Metaphase chromosome types of three species of charrs.

trout. Intercrossing and back crossing have been successful in the arctic charr × brook trout hybrids, but mortality in the F_2 generation has been higher than in the F_1. There are several reasons for the failure of attempts at hybridization. First of all, there can be mechanical difficulties, as when sperm are too large or too small successfully to penetrate into the egg, or in the instance of a cross involving a male of a large species with the female of a small species from which develops an embryo too large for the egg. Secondly there can be differences in length of incubating time, as, for instance, between Atlantic salmon and rainbow trout. Both of these have 60 chromosomes, but differ in length of incubation time by ten days at 50°F. In this case, any fry produced are weak and immature. Third, and most important, is chromosome compatibility by which is meant that each chromosome from the parent species must find a homologue so that normal cell division may occur. Thus, two closely related fish such as the Atlantic salmon, which has 60 chromosomes, and brown trout which has 80 chromosomes, do not hybridize. The first place that a lack of homology becomes apparent is at the time of gamete formation where, if meiosis is irregular, deficient aborted eggs and sperm may result (if they develop at all). For this reason, even successful, vigorous hybrids often prove to be sterile.

Summary and Conclusions

Chromosome numbers are $2N = 84$ in lake trout 80 in the arctic charr and 84 in the brook trout. Brook trout chromosomes are smaller than those of the arctic charr and lake trout. In each of the three species there are eight V-shaped pairs of chromosomes, the rest being rod shaped. One small rod-shaped pair has a very long constriction with a satellite at the end. This pair has not been reported in any other salmonid that has been studied so far, although the smelt has a similar, though much smaller, constriction on a rod shaped pair. Lake trout chromosomes, in particular, have one very long rod-shaped pair of chromosomes, differing from the other charrs in this respect.

Hybridization experiments and cytological evidence indicate that a close chromosome similarity exists among the charrs; closer even than among some members of the genus *Salmo*.

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versity, for providing materials, equipment and helpful advice.

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STATE OF WEST VIRGINIA, CONSERVATION COMMISSION, CHARLESTON, W. VA.

A New Subspecies of *Eumeces dicei* from the Sierra Madre of Northeastern Mexico

RALPH W. AXTELL

IN a previous paper (1958) I reported on a single specimen of *Eumeces dicei* collected at the eastern edge of the Sierra Madre Oriental in the Mexican state of Tamaulipas. In the process of identifying this specimen, I had the opportunity to review the distribution of *dicei* and check some of the more recent material available from northeastern Mexico. Examination of these specimens disclosed that I was dealing with two recognizable forms of *dicei* instead of one. Further comparison with additional material brought to light intermediates between the two forms and corraborated their relationships both morphologically and zoogeographically. The nominal race occurs at rather low elevations on the arid mountain slopes in Tamaulipas and Nuevo Leon, while the form herein described occurs in mesic coniferous forests on the higher mountains of the same two states, and in Coahuila. I suggest that the highland form of this skink be called:

Eumeces dicei pineus subsp. nov.

Fig. 1, A & B

Eumeces dicei Dunn, 1936: 471.—Taylor, 1943: 280 (part).—Fugler & Webb, 1956: 169.

Holotype.—Adult male, UKMNH 39539, collected July 6, 1955, by Robert G. Webb.

Type Locality.—25°12′N–100°24′W, in the Cañon de Carolina, 13 mi. E. San Antonio de las Alazanas, Coahuila, Mexico. Elevation 9,950 ± feet.

Distribution.—(Fig. 2). High elevations (probably in excess of 6,000 ft.) in the Sierra Madre of southern Nuevo Leon, Tamaulipas and extreme southern Coahuila. The Austro-oriental Province (Smith, 1949). The specimens come from the mesic pine and pine-oak forests that are found on the crests and east facing slopes of the Sierra. Presumably all material (although there is no mention in the literature) comes from areas with a limestone substrate. Vertical distribution is from about 6,000 to 10,000 feet.

Diagnosis.—A subspecies of *Eumeces dicei* with rather stout body; maximum, and average adult snout-vent lengths, 62.4 and 59.3 mm. respectively; total length of largest specimen examined 129.8 mm. (♂, tail regen.); limbs separated by 7 to 16 (ave. 13.4) scales when appressed; fore limbs averaging 20 per cent of snout-vent length in males, 18.2 per cent in females; hind limbs averaging 30 per cent of SV. length in males, 27 per cent in females; number of lamellae on fourth toe of pes 11 to 16, averaging 13.4; scales around mid-body 22 to 24 [16–(22), 1–(23), 2–(24)]; primary temporals usually fused with upper secondary temporals (98%); parietals not enclosing interparietal posteriorly; prefrontals usually in contact (14 of 19 contacting); 4–4 supraoculars; first and second supralabials usually subequal in size; color pattern of trunk light dorsally and dark laterally; two rather wide (about one scale width) dorsolateral light stripes extending from region of

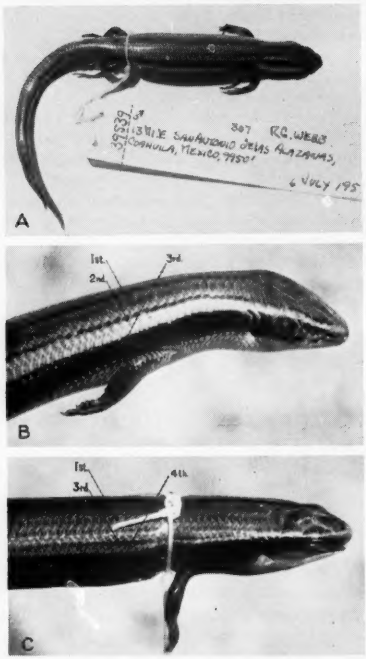

Fig. 1.—(A) *Eumeces dicei pineus*, holotype, adult male, total length 131.3 mm., 25° 12′ N–100° 24′ W, 9,950 ft., Coahuila, Mexico. UKMNH 39539. (B) Dorso-lateral view of *E. d. pineus* (UKMNH 39538, ♀) showing broad, lateral dark stripe extending to third scale row. (C) Dorso-lateral view of *E. d. dicei* (UMMZ 101438, ♀) showing lateral dark stripe extending to fourth scale row.

internasals on snout to point opposite insertion of hind leg (less distinct posteriorly); area between light stripes either unicolor olive-gray or with evidence of two or more dark stripes; sides with broad, brownish-black stripes which reach dorsally to third scale row (Fig. 1, B), anteriorly to nares (seldom lighter in temporal area), and posteriorly over both legs to terminate on proximal part of tail; lighter parts of supralabials, chin and anterior gular area usually reddish in living males (yellowish-white in alcohol); belly and subcaudal surface pigmented with scattered dark specks undertoned with bluish-gray in alcohol, probably lighter in life; tail metallic blue in juveniles, either ground color (brown) or reddish in adults.

Description of type.—Body moderately robust, similar to *E. brevirostris* and *E. dugesi*; rostral about same size as mental, separated from frontonasal by supranasals; frontonasal broader than long, connected by short suture to frontal posteriorly and contacting anterior loreal laterally; prefrontals slightly smaller than frontonasal, pentagonal, not in contact medially, and touching both loreals, first superciliary, first supraocular and frontal; paired frontoparietals connected anteriorly for about one-half their length; interparietal about same size as frontoparietals and about same width as frontal at widest point, not enclosed by parietals; parietals large, same size as or slightly smaller than anterior nuchals, and forming a broad suture with upper secondary temporals; two pairs of well differentiated nuchals, anterior pair by far largest; four supraoculars, first and last about equal in size, second slightly larger than third, and both larger than first and fourth; first three supraoculars contacting frontal; nasal divided by nares and ventral suture; no postnasal; anterior and posterior loreals present, anterior longer than wide and projecting above top margin of posterior to contact with frontonasal; posterior loreal only slightly wider than long, larger than anterior loreal and bordering second and third supralabials; six superciliaries, first slightly larger than second; two very small preoculars; two presuboculars, two small postoculars and three postsuboculars, all about equal size; eye rather small, long axis of orbit less than distance between eye and nostril; lower eyelid with thin upper series of scales (longer than wide), next lower series much larger, and wider than long; lower secondary temporal present, but not contacting primary temporal; both tertiary temporals present, but second tertiary temporal not reaching auricular opening; supralabials 7–7, with first only slightly larger than second and sixth not much smaller than seventh—sixth and seventh contacting upper secondary temporal; seventh labial separated from auricular opening by two minute postlabials; undivided postmental larger than mental; infralabials 7–7, with last elongate and partially hidden beneath supralabials; three pairs of chinshields, first two connected medially, third separated; postgenial much longer than broad; ear opening rather small, rounded (not elliptical), surrounded by 14 scales, two small lobules on anterior border; dorsals slightly wider (2 mm.) than laterals (1.9 mm.) or ventrals (1.7 mm.); manus with prominant thickened scale on outer edge of wrist; enlarged scales on palm not conspicuous; two enlarged scutes at bast of heel, and two large, but less bulbous scutes near base of

Fig. 2
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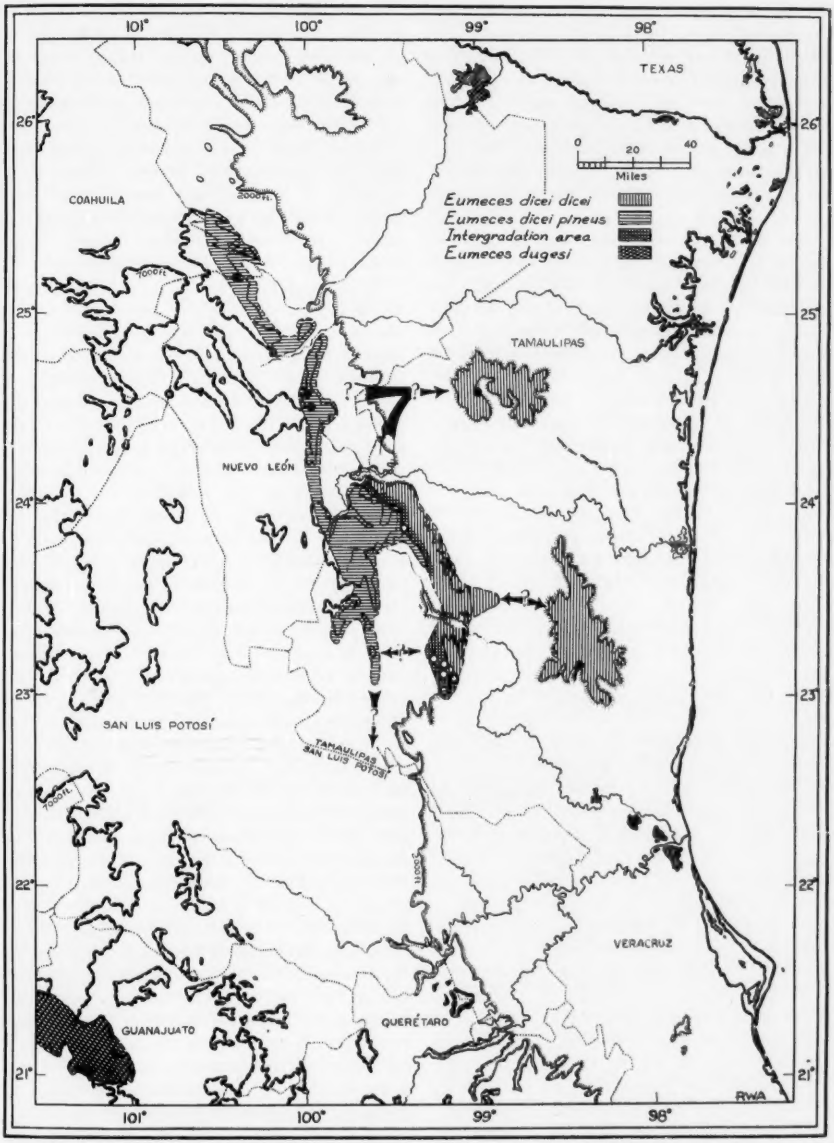

Fig. 2.—Map of the hypothetical range of *Eumeces dicei* and a close relative *Eumeces dugesi*, with black dots representing locality records for the nominal forms and open circles the intergrades. The 2,000 foot contour is represented by hached lines, and the 7,000 foot contour by bold dashed lines. Arrows with question marks show possible routes of dispersal and, or migration.

first toe; only dorsal and ventral series of scales on digits, no lateral; median subcaudals about twice as wide as adjacent lateral scales; six preanals, two enlarged median scales overlapped by smaller laterals; no differentiated lateral postanal.

Color pattern (alcoholic) light dorsally, dark laterally and light ventrally (not so light

as dorsum); two rather wide, light dorso-lateral stripes (occupying part of second and third dorsal scale rows at midbody) extending from rostral to above insertion of hind leg; thin, dark lines well defined anteriorly, but discontinuous posteriorly (pass through medial edge of second scale row) bordering dorsal edge of stripes; median dorsal area brownish-gray with bronzy metallic hue; top of head between stripes slightly more brownish than rest of body, and small black spot on anterior section of frontal; dorsal coloration continues on tail for short distance, but becomes less brownish; tail grayish-black above, slightly darker laterally, dirty white ventrally, dark brownish-black stripe commences on anterior part of nasal, extends back through eye, includes lower three-fourths of upper secondary temporal and upper third of sixth and seventh supralabials, extends posteriorly over front leg to above insertion of hind leg; dark lateral pigmentation on tail not extensive, but evident; lateral stripe includes lateral tip of third, ventral part of fourth and dorsal three-fourths of fifth scale rows; lower part of supralabials, infralabials, chin and throat dirty white (not opaque); belly (beneath lateral stripes) bluish-gray; dark pigmentation of venter begins posterior to foreleg insertion and extends to vent; gular region mottled; limbs dark brownish-black above, lighter below.

Snout to posterior lip of vent 60.3 (all lengths in mm.); tail 71.0 (regenerated); hindleg 18.3 (ratio hindleg to SV. length .303); foreleg 13.0 (ratio foreleg to SV. length .215); head length 11.5, width 8.4; snout to posterior edge interparietal 9.5; axilla-groin 34.7; circumferential scales between head and insertion of foreleg 26, at midbody 22 and in front of hindleg 22; 9–9 lateral scales between appressed limbs; lamellar count for manus 5–9–12–14–8 (R), 5–8–12–13–8 (L); for pes 11–16–12–9–6 (R), ?–15–13–9–? (L); 57 dorsal scales from parietals to above vent.

Comparisons.—*Eumeces dicei pineus* differs from *E. d. dicei* in having 1) a larger average adult size (SV. in *pineus* 59.3, in *dicei* 50.7); 2) dorsal margin of lateral dark stripe reaching third dorsal row on each side at midbody (95%); 3) longer legs in proportion to snout-vent length in both sexes (foreleg/SV. —♂ 21%, ♀ 18% in *pineus*, ♂ 17%, ♀ 16% in *dicei;* hindleg/SV. —♂ 30%, ♀ 27% in *pineus*, ♂ 26%, ♀ 21% in *dicei*); 4) prefrontals usually in contact medially (79%); 5) fewer scales between appressed limbs (in *pineus* ♂ 7–11, ave. 9.3, ♀ 7–16, ave. 12.3; in *dicei* ♂ 12–14, ave. 13.0, ♀ 17–19, ave. 18); 6) first supralabial usually equal in size to second and third; 7) scales around midbody usually 22 (84%); 8) two wide (about one scale width), light dorso-lateral stripes from snout to above insertion of hindleg; 9) light area between dorso-lateral stripes without dark spots or lines, or with poorly defined lines, variable in number; 10) broad lateral dark stripes usually uninterrupted in temporal area by reduction of pigmentation (in *dicei* stripe is interrupted by less pigmentation).

Relationships.—Taylor (1935: 485) tentatively placed *dicei* in the *Brevirostris* group and stated that it "probably represents a very degenerate (specialized) member". With the acquisition of a sample large enough to achieve an idea of the variation within the species, and with the recognition of a larger highland relative, the relationship of *E. dicei* to the *Brevirostris* group now appears closer than Taylor at first imagined. Of the diagnostic characters pointed out by Taylor (p. 482) none appear to be entirely restricted to *dicei*, as all of them occur singly or in different combination in other members of the group. By my interpretation of the present distribution pattern of the *Brevirostris* group, *dicei* (Fig. 2) appears to be isolated in the mountainous regions of northeastern Mexico, and therefore should be free of genetic interchange with the other group members occuring farther south. For this reason I am considering *dicei* as a full species. If, in the future, this skink should be taken in the Mexican states of San Luis Potosi or Hidalgo, its specific status may require reconsideration. In terms of distance and similarity of habitat, the area inhabited by populations of *Eumeces dugesi* in central Guanajuato, Mexico, seems to approach *dicei* populations most closely. The distance between known populations of these two forms is considerable (about 200 miles) however, and the isolated nature of habitats "suitable" for members of the group tends to support the premise that *dicei* is, and has been isolated in northeastern Mexico for some time. Not to be overlooked of course is the possibility that the populations of *E. brevirostris* known to occur in the forested regions of western Durango, Mexico, might have affinity with *dicei*. If this should be the case, additional evidence would be lent in support of Martin's (1958:90) theory regarding a prerecent trans-plateau migration route across the Mexican states of Durango and Zacatecas.

The relationships between the six currently

recognized allopatric species of the *Brevirostris* group is indeed very close and future work will no doubt show some of them to be infraspecific in rank.

Habits and habitat.—Fugler and Webb (1956), who participated in collecting the type series, report that individuals were found on the ground under logs or wood cuttings. Some were found under bark or upright stumps suggesting aboreal tendencies. Although not mentioned by Fugler and Webb, the area in which *pineus* was collected is described by Baker (1956) as being in the Canadian Life-zone. Baker states: "The highest parts of the Sierra Madre Oriental, east of San Antonio de las Alazanas and at the border of Nuevo Leon, possess extensive stands of aspens. In the Sierra Madre Oriental the pine-fir-aspen forests, above 9000 feet in elevation, are mesic and luxuriant."

Like many high elevation lacertilians, *E. d. pineus* is ovoviviparous. Four gravid females collected on July 6 and 7 (UKMNH 39538, 39547, 39549, 39552) contained three embryos each. The embryonic yolk sac size varied little within individual females, but between individuals there was considerable variation. In UKMNH 39547 the sacs were practically absorbed, while in UKMNH 39538 they were slightly smaller than a pea (diam. 6 mm.). The embryo size varied with yolk sac size as would be expected. Maximum, average and minimum snout-vent and tail lengths 23.0, 26.2, 20.0 and 20.6, 16.0, 15.0 mm. respectively. The tail length varied considerably, some were longer, some shorter than the snout-vent measurement. Estimating from the size of the embryos and yolk sacs it could be assumed that birth takes place through July and early August. Scalation and coloration of the embryos are distinct and very similar to that of the adults. The light dorsal-lateral stripes extend the entire length of the body and appear to be more distinct than the stripes of the adults. Of the four embryonic litters examined, three were all females and one was composed completely of males. This may indicate complete unisexuality in the litter compliment of this skink. Further investigation of this facet of *Eumeces* life history would be worthwhile.

Locality records.—Eumeces dicei pineus (19 specimens examined). MEXICO: *Coahuila.*—25°12′N–100°24′W, San Antonio de las Alazanas, 9,950 ft (UKMNH 39533–4, 39536–43, 39545–50, 39552–54). *Nuevo Leon.*—24°31′N–99°58′W, Cieneguillas, 8,400 ft. (Dunn, 1936); 24°36′N–99°59′W, Pablillo, 8,200 ft. (Dunn, 1936).

The recognition of *Eumeces dicei* as a ditypic species necessitates a redefinition of the nominal form.

Eumeces dicei dicei Ruthven and Gaige

Eumeces dicei Ruthven & Gaige, 1933: 1.—Taylor, 1935: 482.—Taylor, 1943: 280 (part).—del Campo, 1953:136—Martin, Robins & Heed, 1954:44.

Type.—Adult female, UMMZ 69253, collected April 3, 1933, by Lee R. Dice.

Type Locality.—24°38′N–99°01′W, Marmolejo, in the Sierra San Carlos, Tamaulipas, Mexico. Elevation 2,500 ± ft.

Distribution.—(Fig. 2). Known from two isolated mountain masses, the Sierra San Carlos and the Sierra de Tamaulipas, and from the lower eastern slopes of the Sierra Madre Oriental in the Mexican state of Tamaulipas. Probably occurs in similar areas in Nuevo Leon. The southern part of the Tamaulipan Province of Smith (1949). Apparently common in oak-pine and oak woodlands where a limestone substrate is present. Vertical distribution from about 2,000 to 5,000 feet.

Diagnosis.—A small subspecies of *Eumeces dicei* with more slender body; maximum and average adult snout-vent lengths 54.5 and 50.7 mm. respectively; total length of largest specimen examined 133.5 mm. (♀); limbs separated by 12 to 19 (ave. 15.5) scales when appressed; fore limbs averaging 17 per cent of snout-vent length in males, 16 per cent in females; hind limbs averaging 26 per cent of SV. length in males, 21 per cent in females; number of lamellae on fourth toe of pes 10 to 14, averaging 12.2; scales around mid-body 22 to 24 [2–(22), 3–(24)]; primary temporal fused with upper secondary temporal; parietals not enclosing interparietal posteriorly; prefrontals variable in contact (2 of 5 contacting); 4–4 supraoculars; first supralabial usually larger than second and third; color pattern of trunk slightly lighter dorsally than laterally; two light dorso-lateral stripes (usually narrower than one scale in width) extend from region of internasals on snout to region just posterior to foreleg insertion; area between light stripes usually not unicolor, but darkened by spots of dark pigment (forming a lineate pattern) in center of each scale; dorso-lateral light stripes margined laterally by broad dark stripe which reaches dorsally to fourth scale row (Fig. 1, C), anteriorly to nares, and extends over both limbs to terminate on proximal part of tail; most of supra-

labials, jowls, chin and anterior part of throat unpigmented or lightly pigmented; gular region of throat, chest, belly and subcaudal surface usually pigmented; tail blue in juveniles, darker ground color in adults.

Locality records.—Eumeces dicei dicei (5 specimens examined). MEXICO: *Tamaulipas.* —23°43′N–99°09′W, Ciudad Victoria, 1,500 ft. (RWA 532); 24°38′N–99°01′W, Marmolejo, 2,000 ft (UMMZ 69253); 23°09′N–98°25′ W, Acuna, 3,000 ft. (UMMZ 101434, 101437–8). *Nuevo Leon.*—10 Kms. S. Monterrey (del Campo, 1953).

Intermediates between E. d. dicei and E. d. pineus

Natural "proof" that two subspecies exist is acceptable only after intermediates or intergrades ideally located in a narrow zone of intergradation are reported, or after exhaustive laboratory work shows two organisms from different populations to be completely interfertile. Modern systematists have, in general, reduced the application of this requisite mostly to hypothesis and now imply the presence of intermediates merely by describing subspecies. It is unfortunate that many systematic studies do not include information or analyses with regard to zones of intermediacy between subspecific populations, for it would add much to our understanding of the dynamics of natural animal populations as well as enhance our zoogeographic concepts. Some well founded complaints against the study of intergradation zones and their delimitation are that they are sometimes very difficult to find and after locating them one is not completely sure of his discovery, unless a very large and agreeable mass of data is at hand.

In the case of *Eumeces dicei*, it seems highly probable that intergrades between *dicei* and *pineus* have been found. Fortunately, the intergrade sample is almost as large as the sum of the nominal form sample, so there is no derth of data (Table I). It is evident from perusal of the table that these lizards are meristically and morphologically intermediate. In pattern and color, however, the intergrades tend to favor *dicei* more than *pineus*. The credibility of the intergrade population is somewhat jeopardized by the fact that most of the intermediates are located not between the nominal populations, but at the southern periphery of the range of one of these populations (Fig. 2). This situation is difficult to explain, and indeed may not need explaining if future collecting brings to light annectant populations. Under present climatic conditions this hardly seems possible, however, for the higher mountains in the region where the intermediates occur (Gomez Farias region of southwestern Tamaulipas) are well isolated from other mountains high and wet enough to maintain a habitat suitable for *Eumeces dicei pineus* (See Martin, 1958:28). The isolated nature of the Gomez Farias highland region leads to speculation about and a possible explanation for the apparent intermediate population in that area. Perhaps in the past, populations of *Eumeces dicei pineus* or some genetically similar lizard occured in suitable habitats on several of the higher mountains in the Gomez Farias region. These lizards may have subsequently come into contact with reproductively compatible lowland congeners and secondarily have become diluted (secondary intergradation), thereby taking on the appearance of the lowland form. Concurrently, heterosis and selection would tend to maintain a continuously adaptive genotype better suited for high elevation existence. The materiel for this part of the genic make-up would logically come from the more primitive, but no longer existent highland germ line.

I have been able to find only one other specimen possessing intermediate characters. This lizard (UMMZ 111150) was taken in a zone between the nominal populations (Fig. 2), but at a higher elevation than one would expect intergrades to occur (6,100 ft.). It is hoped that future exploration in the mountains of southern Tamaulipas and Nuevo Leon will bring further intermediates to light.

Locality records.—Eumeces dicei dicei × *Eumeces dicei pineus* (23 specimens examined). MEXICO: *Tamaulipas.*—23°04′N–99° 14′W, Agua Linda, 5,900 ft. (UMMZ 108508–3 sp., 111149); 22°57′N–99°13′W, Aserradero-del, Paraiso, 1,650 ft. (Martin, 1958); 23°12′ N–99°19′W, Lagua Zarca, 4,800 ft. (UMMZ 111148, and Martin, 1958); 23°09′N–99°18′ W, nr. La Joya de Salas, 5,100–5,200 ft. (UMMZ 101435–6, 110741–2 sp.); trail Gomez Farias to La Joya de Salas, 5,000 ft. (UMMZ 102973–4); 23°05′N–99°11′W, Rancho del Cielo, 3,500 ft. (UMMZ 102975-5sp., 102976, 110742–2sp.); 23°52′N–99°26′W, El Chihue, 6,100 ft. (UMMZ 111150).

Acknowledgements.—I wish to express my sincere thanks to the persons and institutions who have contributed to and cooperated in this study. For loan of specimens I am grateful to Dr. Charles F. Walker and Mr. Thomas M. Uzzell of the University of Michigan Museum of Zoology (UMMZ), and to Mr. John

TABLE I
COMPARISONS OF THE INTERGRADES OF *EUMECES DICEI* WITH THE NOMINAL SUBSPECIES *E. D. DICEI* AND *E. D. PINEUS*

	dicei N = 5	intergrades N = 24	pineus N = 19
Prefrontals			
contacting	2	11	14
not contacting	3	13	5
Ave. no. scales betw. appressed limbs			
♂	13.0 (2)	13.6 (15)	9.3 (6)
♀	18.0 (3)	15.0 (5)	12.2 (13)
Ave. no. lamellae on 4th. toe of foot	11.8 (4)	13.0 (24)	13.5 (19)
Scales around mid-body			
22	2	9	16
23	3	2	1
24		12	2
26		1	
Ave. no. dorsals			
♂	61.5 (2)	55.7 (16)	58.3 (6)
♀	61.3 (3)	58.4 (5)	61.2 (13)
Ave. foreleg/SV. length of adult			
♂	.168 (1)	.198 (11)	.205 (4)
♀	.161 (3)	.169 (3)	.182 (6)
Ave. hindleg/SV. length of adult			
♂	.257 (1)	.275 (11)	.303 (4)
♀	.211 (3)	.243 (3)	.269 (6)
Dorsal edge lateral stripe on 3rd. or 4th. scale row			
3rd	0	10	18
4th	4	13	1
Width anterior light stripe			
½	5	16	
¾	0	7	4 yg.
1	0	0	15
Lateral light stripe to over hind leg			
yes	0	0	15
no	5	24	4 yg.
Area between light stripe			
spot	3	16	0
none	1	4	3
stripe	0	0	15
Dark temporal area			
dark	0	14	16
inter.	2	5	2
light	3	5	1

M. Legler of the University of Kansas Museum of Natural History. (UKMNH). Dr. Walker was kind enough to supply me with pertinent information on the Gomez Farias collection. Specimens in my personal collection are marked RWA.

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Young of the Salamander, *Plethodon jordani melaventris*

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Virtually nothing has been written concerning the young of the several races of *Plethodon jordani* with the exceptions of Wood's (1947a) paper on juveniles of the nominate race and his description (1947b) of a single juvenile of *P. j. shermani*. The detailed study of variation in 138 topotypes of *P. j. melaventris* by Howell and Hawkins (1954) included individuals as small as 28 mm. in snout-vent length. Although Schwartz (1957) sampled throughout an annual cycle, he found no individuals of *P. j. clemsonae* with a snout-vent length less than 23 mm. This lack of data on young plethodons of the *jordani* group may be related to the cryptic coloration and secretive habits of the young salamanders.

The individuals discussed in this paper were collected from June 12 through July 14, 1959 at Highlands, Macon Co., and at Granite City, Jackson Co., North Carolina.[1] The salamanders were killed in chlorotone; color notes and various measurements were taken prior to fixation in formalin. All measurements were made to the nearest millimeter. Body length, as referred to below, represents the distance from tip of snout to the anterior margin of the vent; head length, from gular fold to tip of snout; head width, the widest point on the head. Total length was measured by laying the salamander along a millimeter rule. Tail length may be determined by subtracting body length from total length.

The first young found (4) were flushed from wet leaf litter within a cave-like opening created by massive block faulting. Subsequent examination of wet leaves, especially at, or slightly above, their intersection with the loam, revealed additional juveniles. At night, the young salamanders were taken from rock faces near the intersection of stone and leaf litter. Still others were found on rainy nights crawling over surface debris and on leaves of herbs to a height of 12 inches. Usually if a single young animal was seen, diligent search would reveal others in close proximity.

Fifteen individuals, 20 mm. or less in body length, were taken in 8 samples, 11 from 5 collections at Granite City, the remainder at

[1] This report received support from a Grant-in-Aid from the National Science Foundation administered through the Highlands Biological Station. I wish to thank Prof. Thelma Howell for the many courtesies extended during my residence at the station.

Highlands. Individuals measuring 20 mm. or less were present in samples taken as late as July 14. Juveniles measuring 26 to 40 mm. or more in body length were present in samples taken as early as June 12. The presence of the larger individuals in early June, and of the smaller ones in mid-July indicates either (1) a differential growth rate within the populations or (2) an extended reproductive season. The latter has been suggested by Howell and Hawkins (1954) after examination of the adult reproductive organs.

Measurements

The measurements of 34 young salamanders are summarized in Table I. The maximum body length at which a salamander is referred to as "young" is 25 mm. Individuals larger than 25 mm. usually have the dorsal coloration of adults.

The mean tail length/total length ratio of 27 young salamanders was 0.46; that of 17 individuals in the body size range 30–39 mm., 0.55; of 14 in the range 40–49, 0.56; and of 14 in the range 50–59, 0.56. The data suggest that initially the tail grows in length proportionately faster than the body.

Coloration

Dorsal ground color. The basic color of the smallest individuals varies from a light tan to brown. The largest individual having this juvenile ground color was 25 mm. in body length. Of 37 animals whose body length varied from 17 to 25 mm., the color of 30 was a shade of tan or brown, that of 6 was intermediate between the color of juveniles and the blue-black of adults, and one was blue-black. The body lengths of the intermediates were as follows: 18 mm. (1 individual), 21 (1), 22 (2), and 24 (2). The single blue-black animal measured 25 mm.

Among 74 salamanders whose body length varied from 26 to 45 mm., 5 were intermediate and the remainder, blue-black. The body lengths of these intermediates were 26 mm. (1), 31 (2), 33 (1), and 35 (1).

The juvenile ground color blends with that of dead leaves, on or in which the salamanders are found, so strikingly, that they are almost invisible from a distance of five feet.

Brassy specks. The coloration of 70 individuals was examined with and without magnification (20 ×) immediately after death. Fifty of these salamanders were juveniles (body length, 17–45 mm.). No distinct pattern similar to that observed by Wood (1947a) was seen. Superimposed on the chromatophores of the ground color in 27 individuals (body length, 17–39 mm.) were brassy chromatophores (iridophores) similar to those observed in *P. j. clemsonae*. The brassy specks were restricted to the head of 16 individuals, and could be detected most frequently on the upper eyelids. The specks occurred on the head, body, tail and occasionally, limbs of 11 other animals. The specks were visible to the naked eye in 7 individuals.

There is no correlation between body size and either the occurrence or the extent of brassy marking among the juveniles. Of 26 young salamanders (body length, 17–25 mm.) examined, 8 lacked the specks, 7 had them on the head, body, tail and limbs, and 11 had them on the head and cheeks only. Twenty-four individuals in the size range 29–45 mm. were examined with the following results: 15 lacked specks, 4 had them on the head, body, tail and limbs, and 5 had them on the head and cheeks only. All of 20 adults from Highlands with body lengths exceeding 50 mm. lacked brassy specks.

Howell and Hawkins (1954) reported no brassy color in their *melaventris* sample. They did find white spots variously distributed on 18 specimens. Under higher power (25 ×) iridophores vary from a distinctly hair-like, dendritic appearance (most frequently seen on the head and eyelids of specimens possessing a mere trace of brassy color) to a heavy speck (seen on the tail, lateral body wall, dorsum and cheeks). Heavy concentrations of the brassy pigment appear as white specks on the cheeks of two individuals (39 and 45 mm.). Transitional specks present on the 39 mm. individual lend support to the idea that some white specks may be derived from iridophores (see Rabb, 1955). In formalin the hair-like brassy iridophores disappear. The heavy concentrations persist as dull gray or white specks. The loss of brassy color after preservation has been reported by other investigators (see Schwartz, 1957).

Table I

A Summary of the Measurements (mm.) of Thirty-four Juveniles of *Plethodon jordani melaventris*

	Total Length	Snout-vent Length	Head Length	Head Width
Mean	38.9	20.7	6.2	4.4
± SD	4.7	2.3	—	—
Range	31–49	17–25	5–8	4–5
Number	27	34	34	34

In terms of the two populations, 16 (62%) of 26 juveniles examined from Highlands possess brassy specks, as do 11 (45%) of 24 juveniles from Granite City. If the twenty adults mentioned above are added to the sample, then 35 per cent (all of which are sexually immature) of the Highlands sample have some degree of brassy specking.

Mention should be made of five young plethodons collected at Bee Gum Gap at the foot of Rabun Bald Mountain, Rabun Co., Georgia. These salamanders are presumably referable to *P. j. rabunensis,* since they are all light brown in color. The young of *Plethodon glutinosus,* a species that also occurs at this station, are reported by Highton (1956) to show a uniformly black ground color. A single animal, measuring 38 mm. total length and 20 mm. body length, was profusely spotted with fine brassy specks on the head, body, tail, limbs, and cheeks. There was much more brassy pigment on this specimen than on any individual examined from Highlands or Granite City. Four other young (21–25 mm.) lacked the brassy pigment entirely. Schwartz (1957) reported the occurrence of brassy pigment in the population on Rabun Bald Mountain.

Venter. Individual and geographic variation in the intensity of ventral coloration of adults and subadults has been studied by Howell and Hawkins (1954), Bailey (1937), Hairston and Pope (1948) and others. Studies of the ontogenetic development and variability of the pigmentation have not been previously reported.

Two aspects of the ventral pigmentation are considered here: (1) the infiltration of the venter by melanophores, and (2) the intensity of the color after infiltration. The former may be correlated with body size. The latter varies independently from body size.

The percentage of ventral body surface infiltrated by melanophores was estimated for 102 individuals (body size, 17–45 mm.). The area examined was bounded anteriorly by the gular fold and posteriorly by an imaginary line at right angles to the anterior margin of the vent. Laterally, boundaries were arbitrarily set along an imaginary line from the ventrolateral insertion of the arm to that of the leg. To be as consistent as possible, five individuals were selected as standards, representing 5, 25, 50, 75 and 100 per cent coverage with melanophores. The other 97 individuals were then assigned by estimation (with frequent reference to the standards) to one of four categories: 0–25, 25–50, 50–75 and 75–100 per cent coverage. The results were correlated with body length in a bar histogram (Fig. 1).

Just as the characteristic adult dorsal color, or transitional stages to it, occurs in a few young individuals 25 mm. or less in body length (16%), so do some young individuals (23%) display the adult ventral condition of melanophore infiltration as indicated by their occurrence in the 75–100 per cent category. Only three individuals with a body length greater than 26 mm. have sufficiently large flesh-colored areas devoid of melanophores to be assigned to the 25–50 per cent category. Beyond 32 mm. the majority of the salamanders have the adult condition.

Hairston and Pope (1948) remarked that juveniles of all *jordani* populations have pale bellies. Howell and Hawkins (1954) mention the lack of agreement in the meaning of the terms, "light grey", "dark grey", and "black". They discerned varying degrees of darkening,

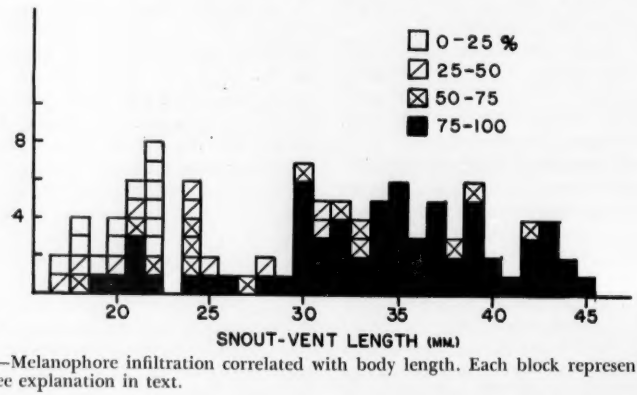

Fig. 1.—Melanophore infiltration correlated with body length. Each block represents one individual. See explanation in text.

with 94 per cent of their samples ranging from light gray to dark gray, and only 5 per cent with a decidedly black venter.

Among the individuals in my samples in which maximum infiltration has occurred, the color intensity ranges from light gray to dark gray, with the venters of the majority ranging toward the lighter shades. No individuals have a black belly, the most positive characteristic of *P. j. melaventris*. Inspection of the entire series indicates that intensity is related to (1) the size of the melanophores and (2) the amount of anastomosis between adjacent melanophores. Whereas no measurements were made, melanophore size in general increases with body size, thus tending to produce darker venters in larger individuals. The degree of anastomosis varies independently from body size among the juveniles, and hence may produce dark bellies in the smaller as well as larger juveniles. Maximum anastomosis occurs among the adults. The three juveniles with the darkest bellies (aptly described as dark gray when compared to a black-bellied adult) measure 35, 39 and 44 mm.

Conclusion

The occurrence of brassy specks in populations of *Plethodon jordani* other than those of *P. j. clemsonae* is of considerable interest, since it lends additional support to Hairston's (1950) concept of *jordani* as a polytypic species. Previous evidence for gene flow between *P. j. clemsonae* and *P. j. melaventris* lay in the presence of *melaventris*-like animals in populations recognizable as *clemsonae* (Hairston, *ibid.*; Schwartz, 1957). Schwartz's report (*ibid.*) of brassy specks in *P. j. rabunensis* is confirmed. The presence of brassy specks in *melaventris* and *rabunensis* populations is here interpreted as additional evidence of gene flow between the three allopatric populations, *P. j. melaventris*, *P. j. rabunensis* and *P. j. clemsonae*.

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A Population of *Opheodrys aestivus* (Reptilia: Squamata)

Donald W. Tinkle

Little has been published concerning the life history and variation of the keeled green snake. Burger (1947) noted geographic variation in this species, and a thorough study of variation in the related *Opheodrys vernalis* was made by Grobman (1941). Observations on habitat and food of *Opheodrys aestivus* were included in the papers of Clark (1949), Duellman (1949), and Richmond (1952).

The present study was made of samples from Waggaman and Willswood, Jefferson Parish, Louisiana, collected during the months of September through December, 1949. These specimens are deposited in the collections of Tulane University and bear numbers 5422 (1), 10868 (41), 10869 (16), 10973 (1), 10998 (4), 11159 (14), 11214 (45) and 11365 (20). I wish to thank Dr. Fred R. Cagle of Tulane University for making these snakes available for study.

Variation

Meristic characters selected for study were the numbers of scale rows (at midbody), ventrals, caudals, supralabials, infralabials, preoculars, postoculars, and temporals. There was little variation except in ventrals and caudals; other scale counts were discontinued

after examination of 50 snakes. Six supralabials were present in one snake (2 percent), seven in 48 (96 percent), and one (2 percent) had seven on one side and eight on the other. Six infralabials were present in 2 (4 percent), seven in 44 (88 percent) and eight in 2 (4 percent). An instance of six on one side and seven on the other and an instance of seven and eight were recorded. Forty-seven snakes (94 percent) had one preocular; one (2 percent) had two and two individuals had one on one side, two on the other. Postoculars were one in 2 snakes (4 percent) and two in 45 (90 percent). Two instances of one on one side and two on the other and one of three and two were noted. A temporal count of one anterior and two first posterior was obtained from 47 (94 percent) of the specimens. One snake (2 percent) had counts of 1–2 and 1–1; one (2 percent) of 1–2 and 1–3; and one (2 percent) of 2–2.

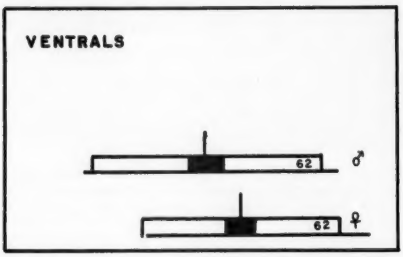

Fig. 1.—Variation in ventral and caudal number in *Opheodrys aestivus*. Each bar graph shows the range, mean, two standard deviations and two standard errors on each side of the mean.

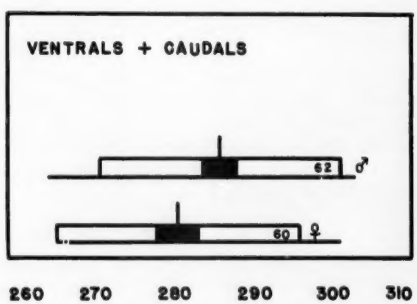

Fig. 2.—Variation in combined ventral and caudal number in *Opheodrys aestivus*. Each bar graph shows the range, mean, two standard deviations and two standard errors on each side of the mean.

Ventral scale counts were made by the method suggested by Dowling (1952). The number of scales anterior to the point of juncture of the first dorsal scale row with the ventrals was found to vary from one to four using the ventral scale definition of Schmidt and Davis (1941). Caudal scales were counted beginning with the first pair meeting in the midline posterior to the anus. A variable number of small irregular scales lying lateral to the anus did not meet in the midline.

Sexual Dimorphism—There is a significant difference (T = 3.6) between the mean number of ventral scales in males and females (Fig. 1), but the difference in the mean caudal number is more significant (T = 8.3; Fig 1). A greater sexual dimorphism in mean caudal number than in mean ventral number was also found in *Opheodrys vernalis* by Grobman (1941). The range in *Opheodrys aestivus* (145–163) overlaps the range of ventral scale counts (116–154) reported by Grobman in *Opheodrys vernalis*. All of this overlap is due to the higher counts in *O. v. blanchardi*; there is no overlap between *O. v. vernalis* and *O. aestivus*. The difference in the caudal scale counts in the two species of green snakes is enormous. There are 60–96 caudals in *vernalis* according to Grobman's data, while my data on *aestivus* show a range from 113–144. The range of variation is nearly the same for the two. The size of the caudals was found to average 2.1 mm. in males and females with little variation indicating that the greater caudal number of males is due primarily to a longer tail rather than smaller caudal scales.

The mean numbers of combined ventrals and caudals are significantly different (T = 4.1); as might be expected the mean difference is greater than that between mean ventral numbers, but less than between mean caudal differences (Fig. 2).

The tail length was found to be from 53.5

to 70.3 per cent of the body length (snout to vent) in males (mean 63.0) and from 50.9 to 66.6 in females (mean 59.8).

Edgren (1951) showed that there was sexual dimorphism in the position of the yolk sac scar in juvenile hog-nosed snakes (*Heterodon platyrhinos*) and similar observations were made by Richmond (1954) on rainbow snakes (*Abastor erythrogrammus*). No such difference existed between the 13 female and 22 male green snakes in which the yolk sac scar was clearly evident. The extreme anterior position of the scar was on ventral 125 in males, 124 in females; the most posterior end of a scar was on ventral 143 in males, 139 in females. There was less variation in the position of the scar in females than in males. With few exceptions the scar position was directly correlated with the number of ventrals—the greater the number of ventrals the more posterior the anterior end of the scar, as noted by Richmond (1954).

Ontogenetic variation—Dunn (1942) observed that juvenile snakes were sometimes more variable than adults in scalation and suggested that detailed studies should be made of large numbers of juveniles and adults of several snakes. His observations were supported by studies of Inger (1942; 1943) on *Opheodrys vernalis* and *Thamnophis radix*; the juvenile garter snakes had a larger coefficient of variability than the adults in every character examined. To determine whether this held true for *Opheodrys aestivus* I calculated comparable statistics for males and females in two size groups, 101 to 300 mm. and 301 to 500 mm. (Fig. 3). In the ventrals, the variability is reduced chiefly by loss of individuals from the lower extremes as observed by Inger (1943). However, in the females some individuals in the 301 to 500 mm. group showed upper extremes not found in the juveniles. The coefficients of variability for ventral counts are shown below:

	Males	Females
101–300	2.7%	1.8%
301–500	1.8%	2.1%

Sampling errors presumably account for the small increase in the coefficient in the larger females, but the difference between the two groups of males is significant in demonstrating an actual decrease in variability.

The range of variation in caudal number is slightly reduced in older males, but in females it is increased. Extremes at each end are gained by the larger females while in males the loss of variability is due chiefly to losses from the upper extreme, reversing the trend noted by Inger (1943). The actual coefficients of variability are shown below:

	Males	Females
101–300	4.5%	4.1%
301–500	4.2%	4.5%

The changes in coefficient in both sexes from juvenile to adults are much less than one per cent and probably insignificant in demonstrating an actual change in variability in either group. In juveniles, the males have a larger coefficient of variability in numbers of both ventrals and caudals, but in adults this trend is reversed and the females show the greater variability.

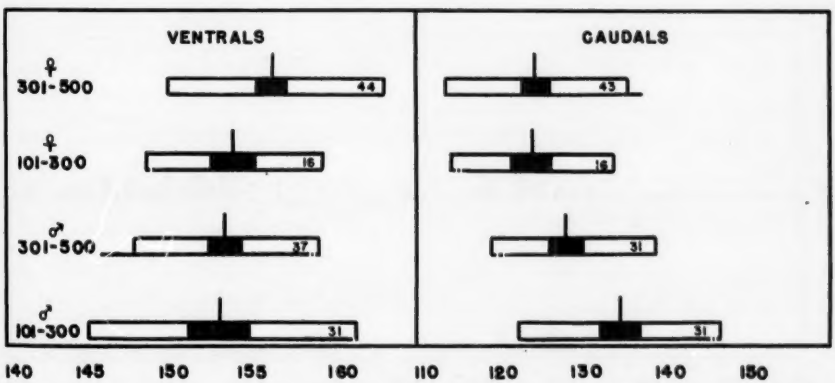

Fig. 3.—Variation in ventral and caudal number in two size groups of *Opheodrys aestivus*. Each bar graph shows the range, mean, two standard deviations and two standard errors on each side of the mean.

Population Structure

Sex Ratio—The sex ratio of 132 specimens in which sex could definitely be determined by dissection was 63 females (47.7 percent) and 69 males (53.3 percent). This divergence from a 50–50 ratio is insignificant (Chi-square = .28).

Ratio of juveniles to adults—In these winter samples the ratio of juveniles to adults should be most indicative of the actual relative percentages because most population increase for the year is present because most of these juveniles were taken during the early winter which is generally mild, before the mortality loses from weather extremes are apparent. Assuming that the means used to determine sexual maturity (see section on sexual maturity) are reliable and recognizing that the criteria for sexual maturity in females are much more reliable than those for males, the following figures are presented: mature males, 38 (30 percent); mature females, 40 (32 percent); juvenile males, 27 (22 percent); juvenile females, 20 (16 percent).

Ratio of size groups—The snakes of both sexes fall into two distinct size groups (Fig. 4). In the juveniles the male and female size groups are nearly the same, but among adults, females over 400 mm. are more frequent than males of this size. There are 39 snakes less than 250 mm. in body length (30 percent) and 89 greater than 250 mm. (70 percent). It is tempting to speculate that two age classes are present in the population, young of the year represented by snakes below 250 mm. and snakes in their second season by the others, but it is more likely that rapid growth of second season snakes and slower growth of those in third or later seasons has blended the latter groups and obscured age classes. The figure does indicate, when compared with information on the reproductive tract presented later, that some individuals reach sexual maturity in their second season of growth; this is probably true of other snake species in this area, (Tinkle, 1957).

Reproductive Tract

Ovarian follicles—Thirty-seven females representing all size groups were chosen for obtaining data on the ovarian follicles. The ovaries were examined macroscopically to determine the number and size of follicles greater than one millimeter and the sizes of the oviducts and testes.

The ovaries of those individuals with a yolk sac scar contained a maximum of nine visible follicles with distances of two to four millimeters between them, giving the ovary a loose appearance. The follicles were always less than one mm. in greatest diameter.

The ovaries of snakes in the second size class (Fig. 4) were more compact with a greater number of follicles and less interfollicular space. The follicles in these snakes varied from less than one mm. at 5.9 mm., but most follicles were between two and four in greatest diameter. Seemingly growth in some follicles occurs during the fall and winter; no adult snake caught in September contained ovarian follicles greater than 3.9 mm. in diameter while all adult snakes caught from October through December had follicles larger than 3.9 mm.

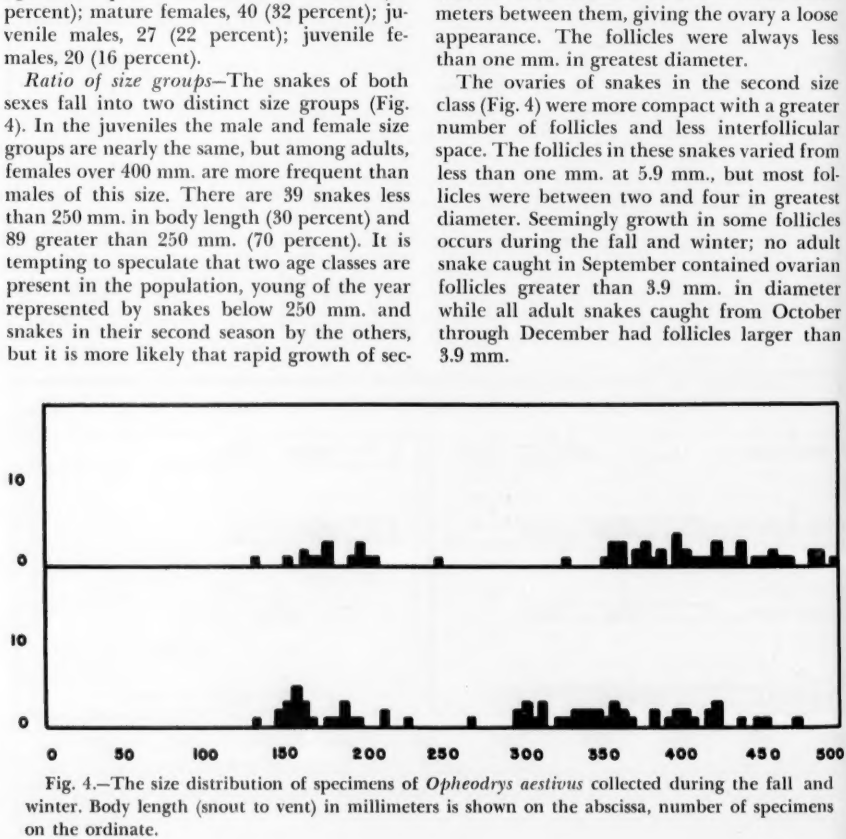

Fig. 4.—The size distribution of specimens of *Opheodrys aestivus* collected during the fall and winter. Body length (snout to vent) in millimeters is shown on the abscissa, number of specimens on the ordinate.

There was a direct correlation between the size of the female and the total number of follicles (Fig. 5); similar correlations have been reported in *Thamnophis sauritus proximus* in this area (Tinkle, 1957) and in *Natrix sipedon confluens* (Tinkle, 1959). The right ovary is longer than the left and anterior to it and usually contains more follicles. The mean follicle number in 17 females excluding young of the year was 9.8 in the left ovary and 13.6 in the right. The number of follicles in the left exceeded that in the right in a single specimen and in a second snake the same number was found on both sides.

Reproductive potential—The many snakes taken in the fall and winter had few distinct ovulation scars and no oviducal eggs or yolk-filled follicles which are the usual bases for estimating reproductive potential. Seven adult females from southern Louisiana collected in the spring and summer were examined. One of those taken in March had follicles that were no greater in size (maximum 4.6 mm.) than those in the winter samples. This was true also of a postreproductive female caught in July. Most follicular enlargement probably takes place after March and ovulation and egg deposition are completed during the next four months. Of the remaining snakes one contained seven oviducal eggs (25–27 mm. in length) with yolk masses averaging 22 mm. The remainder contained from four to ten yolk-filled follicles of from ten to 25 mm. These snakes did not yield sufficient data for conclusions about reproductive potential but they did show that the maximum size of follicles other than those enlarged for that years ovulation was 4.0 millimeters. This indicates that the ovulatory follicles were derived from follicles which during the past reproductive season were larger than 4.0 mm., or that at least were the largest follicles in the post-reproductive ovary.

The number of follicles greater than 4.0 mm. in the winter samples varied from one to nine (mean 4.7). The egg complements of 4–9 reported for this species in the literature (Schmidt and Davis, 1941; Curtis, 1950) fall within this range which approximates the range (4–10) of ovulatory follicles or of oviducal eggs found in the few snakes examined during the spring and summer.

Testes—The maximum size of the testes in the young of the year is 0.8 mm. in greatest diameter and 5.5 mm. in greatest length. The largest testes of an adult snake was 4.0 wide and 22.0 mm. long. The testes in the young of the year are ribbon-like and more

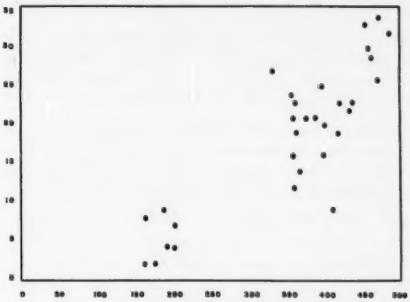

Fig. 5.—Correlation of body length (abscissa) with the number of follicles present in the ovary (ordinate).

opaque than the ovaries. The testes become progressively longer, wider and more cylindrical as the snake increases in size. The right testes is slightly longer than the left and anterior to it.

Size and age of sexual maturity—The smallest female having convoluted oviducts, ovulation scars and ovarian follicles of at least 3.0 mm. measured 355 millimeters in body length. However, four specimens larger than this individual lacked all three evidences of maturity. No specimen larger than 396 millimeters lacked them; therefore, females between 350 and 400 millimeters may be considered in the minimum size group of sexual maturity.

The age at sexual maturity is probably one or two years assuming that the larger size group of snakes (Fig. 4) contains sexually mature individuals of the previous season and others not reaching maturity until their second season.

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The Courtship and Spermatophore of the Salamander *Plethodon glutinosus*

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BISHOP (1941) pointed out that although *Plethodon glutinosus* has been known since 1818, little is known of its habits and life history. Within the past decade, however, *P. glutinosus* has been the subject of several intensive studies. Hairston (1949, 1951) reported on its ecology and relationship with other large species in the genus *Plethodon* in the southern Appalachian mountains. Pope (1949) studied the reproduction and growth of *P. glutinosus* in Virginia and later reported courtship activity in the field during the month of August (Pope, 1950). Highton (1956) studied the life history of *P. glutinosus* in Florida and described the newly hatched young of this species.

The general study on plethodontid salamander courtship by Noble and Brady (1930) included *P. glutinosus* among the species observed. Unfortunately, the details of the courtship pattern and the spermatophore of this wide ranging species have not been described.

During the summer and fall of 1958 in the Mount Rogers-Whitetop mountain area of Virginia, specimens of *P. glutinosus* were maintained in captivity and the complete courtship pattern and the spermatophores of this species were studied. While observations based entirely upon captive salamanders are never as desirable as field observations, they are more desirable than no observations at all.

METHODS

Adults were maintained in small groups of from two to five individuals in large glass finger bowls. The salamanders were kept on a substrate of moist paper toweling and the atmospheric humidity within the containers was presumed to be close to the saturation point. The captives were maintained for periods that did not exceed three weeks. Most of the courtship activity, however, was displayed by salamanders that had been in captivity only a day or two.

Observations at night were made with the aid of a 40 watt white light in a goose-neck desk lamp. The reflector of the lamp was directed away from the containers but sufficient light was present to see the details of courtship.

COURTSHIP

Although captive *P. glutinosus* were kept under observation in August, September, and October, courtship was witnessed only during the month of September. Incomplete courtships were observed on the nights of September 3–4, 7–8, 14–15, and 17–18. The complete courtship sequence through spermatophore deposition was observed on the nights of September 12–13, 19–20, 20–21, and during the morning of September 30.

Courtship typically occurred late at night but on two occasions the salamanders courted during the daylight hours. Both of these diurnal courtships took place on September 30, the first between 10:00 and 11:00 AM and the second between 12:00 N and 3:00 PM Eastern Standard Time.

In general, just prior to courtship, the male becomes active and moves rapidly around the container occasionally touching his nasolabial

grooves to the substrate. During this active searching, the chin, feet, and the white spots of the male gradually change in color from white to pink. In the later stages of courtship, these body areas of the male become reddish in color.

When the male touches a female, his buccopharyngeal movements quicken and he places his nasolabial grooves and mental gland in contact with her head, body, or more often her tail. At this point in courtship, the male begins an elaborate foot-dance. At first, the male generally raises and lowers only his hind limbs. They are raised and lowered either alternately or simultaneously. When the limbs are raised simultaneously, the base of his tail is pressed down against the substrate and serves as a leverage point. As the dance progresses, all four limbs are raised and lowered alternately in place as though the male were marking time. Occasionally, a male will move all of his limbs alternately from the beginning of the foot-dance. These limb movements were timed with a stop watch on several occasions but they were so variable in frequency and pattern that no definite rhythm could be detected.

During this initial stage of courtship, the male holds his mental gland against the body of the female but occasionally raises his head. When the adhesion between his mental gland and the skin of the female breaks, his head is snapped upward. He then lowers his head and reestablishes contact between his mental gland and the skin of the female. This behavior is repeated several times during his gradual movement along the body of the female towards her head.

In addition to raising the head, the male *P. glutinosus* at this stage of courtship engages in another kind of behavior that was not observed in the courtship pattern of *Plethodon jordani metcalfi* (Organ, 1958). As the male moves his snout along the body of the female, he repeatedly grasps the body of the female with his mouth. Prior to grasping the female, the male moves his nasolabial grooves back and forth across the area to be grasped. He then sharply flexes his head downward at right angles to the axis of his body and opens his mouth widely around the dorsum of the body or tail of the female. His grip is retained for a short period of time and then released. Very little pressure is exerted by his jaws and the body or tail of the female often moves freely through the widely gaping mouth of the male.

When the male reaches the head of the female, he keeps his mental gland pressed over her head and particularly over the region of her nasolabial grooves. He then breaks contact between his chin and her head and pushes his head under her chin. The male passes beneath the chin of the female keeping first his back and then the base of his tail in contact with her chin. Throughout these preliminary stages of courtship, the male has continued his foot-dance. As his tail passes beneath the chin of the female, it begins to undulate. The male stops moving forward at this point and remains with the base of his undulating tail arched slightly upward against the chin of the female until she places her forelimbs astride his tail. When this position is attained by the female, the courting pair move slowly forward in a tail-straddling walk.

The tail undulations of a male in the tail-straddling stage of courtship were timed by means of a stop watch during the night of September 14–15 at 21.2°C and were found to be constant. The individual timings based on this one male were 20 waves/21 seconds, 20 waves/21 seconds, 20 waves/21 seconds, 20 waves/21 seconds, 20 waves/22 seconds, and 20 waves/20 seconds. The mean frequency was 1 wave/1.05 seconds.

The tail-straddling stage in captive salamanders was prolonged and one courting pair was estimated to have covered a total distance of 17 feet while moving around the inside of the container in a tail-straddling walk. During this stage of courtship, the male often bends his body laterally into a tight circle, placing his snout close to the snout of the female. This is a difficult position for the male to maintain but he repeatedly thrusts his head towards her snout. This behavior results in brushing the mental gland across the snout of the female. If the female slips back along the tail of the male, he stops moving forward but continues his foot-dance and tail undulations until the female regains her position with her chin on the base of his tail.

Prior to spermatophore deposition, the male stops moving forward and begins a series of lateral sacral rocking motions. The female moves her head laterally in synchronization with, but counter to, the sacral movements of the male. When the male deposits a spermatophore, he lowers his swollen vent to the substrate and has rhythmic muscular contractions in the region of his vent. He then quickly raises his vent and arches his tail upward and to one side, leaving the spermatophore adhering to the substrate. Although the tail of the male is bent sharply to one side, the female keeps her chin against its base and the male

and female move forward rapidly until her vent is over the spermatophore. The female picks up the sperm cap from the spermatophore with her vent and leaves the entire stalk adhering to the substrate. The courting pair may continue in the tail-straddling walk for a short period of time but usually part immediately after the female has picked up the sperm cap.

Females that are obviously reluctant to court either flee from the male or raise the head high when the male attempts to touch her chin with his body. When a female engages in the latter behavior, the male repeats his approach and again tries to place his body under her chin until he either succeeds or until she flees from him. Having encountered a female, a courting male will follow her around the container for several hours trying to place her in a tail-straddling position.

The color change in courting females is not as pronounced as it is in courting males but the chin, feet, and spots of the female usually change in color from white to pink during the tail-straddling stage of courtship.

During the early stages of courtship, both the male and female react to a light being turned on or off in a room and invariably stop courting. During the tail-straddling stage and especially when the male is depositing a spermatophore, both the male and the female are highly insensitive to sudden light changes and continue to court even when a bright flashlight is turned directly upon them.

Sex Recognition and Aggression

Courting males use both olfactory and visual means to locate other salamanders. When the other salamanders in the container are motionless, the courting male searches the container by touching his nasolabial grooves to the substrate while moving around. When he reaches the vicinity of another salamander, his nasolabial grooves are used more frequently until his snout actually touches the other salamander. On the other hand, if one or more other salamanders in the container are moving, the courting male approaches them without using his nasolabial grooves. If a courting male touches another salamander and that salamander flees, the male reacts visually and does not use his nasolabial grooves while pursuing the fleeing salamander.

Courting males approach both females and other males and there are no obvious differences in the behavior of the courting male when approaching one or the other sex. The salamander being approached by the male, however, reacts in one of several ways. If the salamander being approached is a female, she either flees or remains passive. If the salamander being approached is a male, he either flees, remains passive, or attacks the approaching male by biting him viciously on the legs and tail. An attack was the most frequent reaction.

When a courting male attempts to court a passive male, he begins with a foot-dance and holds his mental gland against the body of the passive male. This invariably arouses the passive male who then begins to undulate his tail. When this occurs, the courting male stops courting and attacks the other male, biting and pursuing him around the container. In one of these encounters, the male being attacked lost two inches from the tip of his tail. These vicious bites, inflicted by one male upon another, are in sharp contrast to the gentle grasping of the female during courtship.

The attack of one male upon another always follows direct physical contact and results in the two males keeping at some distance from one another.

Spermatophore

Four spermatophores were deposited while courtship was actually under observation and two were collected before the female could recover them. These spermatophores were deposited during the nights of September 12–13, 19–20, and 20–21 and during the morning of September 30. Additional spermatophores and stalks were found in the containers on the mornings of September 10, 16, and 30. These latter spermatophores and stalks were distorted by the movements of the captives. The description of the spermatophore is based on the two specimens collected on the night of September 20–21 and the morning of September 30. Both were collected immediately after they were deposited by the male and before they could be distorted.

The spermatophore (Fig. 1) is mushroom shaped, bilaterally symmetrical, and slightly compressed from side to side. The sperm cap varies in color from pale yellow to white. It is adhesive and clings to anything with which it comes in contact. In profile, the cap has a small anterior lip near the junction of the cap and stalk. The anterior surface of the cap is vertical whereas the posterior surface slopes downward at an angle and has a deep depression. The sides and top of the sperm cap are smoothly rounded.

The supporting jelly stalk is colorless, transparent, and less adhesive than the cap. The stalk is compressed into a ridge and has a

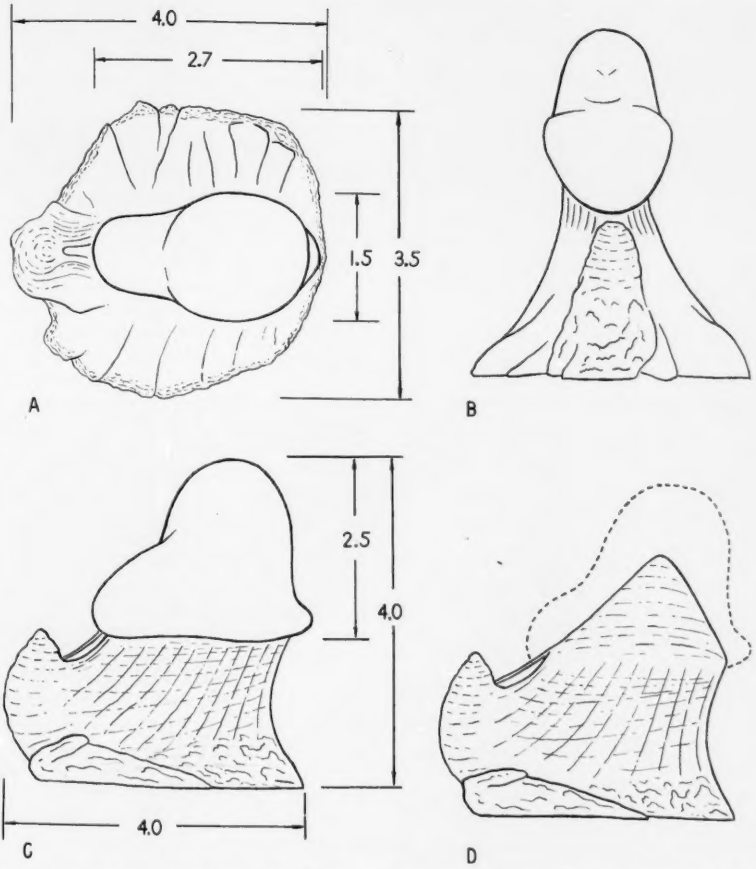

Fig. 1.—The spermatophore of *Plethodon glutinosus*. a.—Dorsal view. b.—Posterior view. c.—Right lateral view. d.—Right lateral view of stalk with the position of the cap indicated by dotted line. All measurements in millimeters.

characteristic mound of jelly behind the posterior border of the cap. The surface of the stalk, when freshly deposited, has many cross-striations. The vertical striations are more deeply incised than those running horizontally. The base of the stalk flares outward to form a broad surface of attachment with the substrate.

The method by which the cap is attached to the stalk is similar to that in the spermatophore of *P. j. metcalfi* (Organ, *ibid.*). The stalk has a conical cusp or spike that projects upward into the center of the cap. During courtship, the female recovers only the sperm cap, which is easily detached from the stalk, and leaves the entire stalk attached to the substrate. The cap is somewhat rigid and retains its characteristic shape after it is removed from the stalk. The cavity into which the stalk had projected remains open.

Discussion

Although *P. glutinosus* was one of the species included in the generalized courtship pattern of plethodontid salamanders by Noble and Brady (*op. cit.*), these workers made no mention of the foot-dance or the grasping action on the part of the male during the preliminary phases of courtship. They did indicate that some males in the tail-straddling walk occasionally turned towards the female and placed the snout close to that of the fe-

male but they failed to indicate which of the species did so. In short, they concentrated on the basic similarities of the courtship patterns of plethodontid salamanders and ignored the details of the individual patterns. There is reason to believe that the courtship behavior of these salamanders is almost as characteristic of the species as are the morphological characters used in describing the species.

The preliminary stages of courtship in *P. glutinosus* resemble comparable stages of courtship in *P. j. metcalfi* closely. In both species there is a foot-dance on the part of the male and he holds his mental gland against the skin of the female. The males of both species characteristically raise the head, breaking the adhesion between the mental gland and the skin of the female, and snapping the head of the male upward. When repeated, this may be a source of the stimulation that arouses the female. Finally, the males in both *P. glutinosus* and *P. j. metcalfi* do not undulate the tail until it is in contact with the chin of the female.

The preliminary stages of courtship in these two species, however, differ in that the *P. glutinosus* male uses his mouth to grasp the body or tail of the female for short periods of time. This behavior was not seen in *P. j. metcalfi*. On one occasion, a *P. j. metcalfi* male actually bit a female in the course of courting her but this was not comparable to the grasping action of the *P. glutinosus* males during courtship.

The tail-straddling stage of courtship is similar in both species but *P. glutinosus* males invariably bend the body into a tight lateral circle and thrust the head towards the snout of the female, thereby brushing the mental gland across her snout. This behavior was seen on only one occasion in *P. j. metcalfi* and apparently is not as necessary to successful courtship as it appears to be in *P. glutinosus*.

The pelvic rocking motions of the males and the lateral head movements of the females immediately prior to spermatophore deposition are essentially the same in both species. The arching and bending of the tail sharply to one side by the male after depositing a spermatophore is also similar in the two species.

The general reddening of the chin, feet, and spots in courting *P. glutinosus* is transitory and disappears a few hours after courtship is completed. This same general reddening was observed but not reported in courting *P. j. metcalfi*. The color change is attributed to dilation of the superficial blood vessels in the skin of courting individuals.

The prolonged tail-straddling walk of most of the captive *P. glutinosus* is considered to be abnormal and due to the confining effect of the 8 inch finger bowls in which courtship took place. One could not escape the impression that the male was trying to align his body and that of the female along a longitudinal axis with sufficient room in front of him to advance in a straight line. This was physically impossible in the finger bowls and it resulted in a low incidence of successful sperm-cap recovery by the females.

Whereas the relative durations of each of the phases of courtship are considered to be unreliable and have not been included in this paper, the sequence of events and details of behavior in the courtship pattern are believed to be similar to the pattern of courtship that would be seen in the field. In view of the similarity of the courtship pattern displayed by *P. j. metcalfi* (Organ, *op. cit.*) in the field and under conditions of captivity, it is reasonable to assume the same similarity for the pattern of *P. glutinosus*.

The basic structure of the spermatophores of *P. glutinosus* (Fig. 2, above) and *P. j. metcalfi* (Fig. 2, below) is similar. In both spermatophores there is a colorless, transparent stalk that has a cusp or spike that projects into the center of the cap. The cap is easily detached from the stalk and is the only portion of the spermatophore actually recovered by the female during courtship. Finally, the cap of the spermatophore of both species is adhesive, somewhat rigid, and does not collapse or lose its shape when detached from the stalk.

The spermatophores of the two species, however, are easily distinguished. The anterior lip of the cap in *P. glutinosus* is smaller than in *P. j. metcalfi*. The stalk in *P. glutinosus* has a characteristic mound of jelly behind the posterior border of the cap but this structure is lacking in the stalk of *P. j. metcalfi*. In the former species the stalk is a compressed ridge but in the latter species it is essentially a conical spike.

Noble and Brady (*op. cit.*) indicated that the olfactory system plays an important role in the recognition of members of the same species. Unfortunately, no cross mating was attempted in the present study. Whereas courting males may distinguish members of their species by olfactory means, they apparently do not distinguish between the sexes by this means. Practically nothing is known about sex recognition in plethodontid salamanders but in *P. glutinosus* the sexes are

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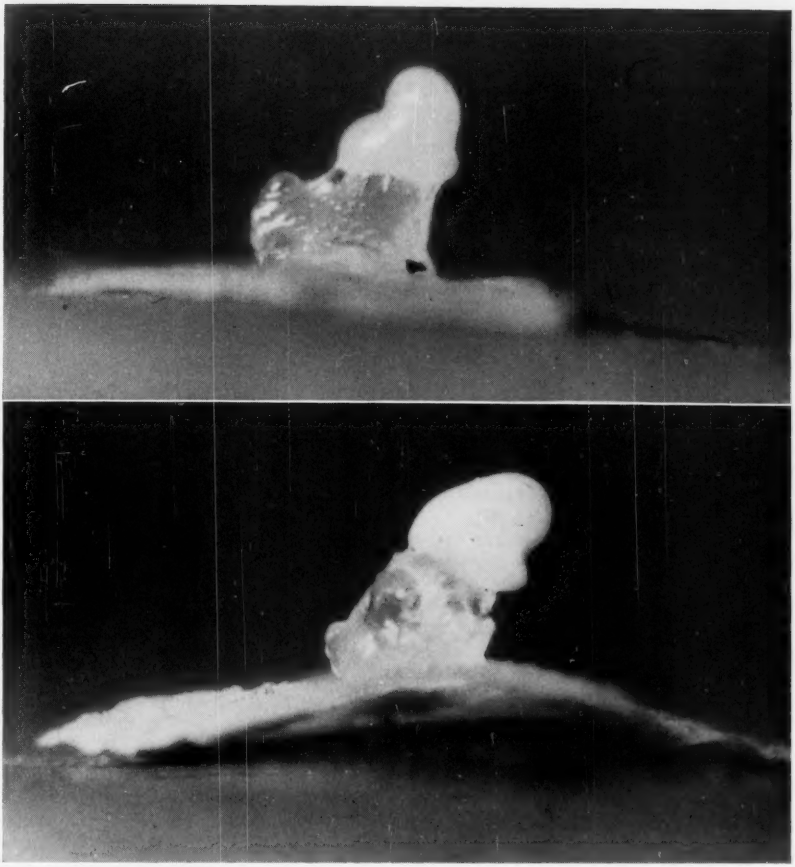

Fig. 2.–The spermatophore of *Plethodon glutinosus* and *Plethodon jordani metcalfi*.

ABOVE. Spermatophore of *P. glutinosus* deposited at 1:02 AM on September 21, 1958 and photographed shortly thereafter. Right lateral view.

BELOW. Spermatophore of *P. j. metcalfi* deposited at 12:05 AM on September 20, 1958 and photographed on September 21, 1958 after preservation. The spermatophore is tilted forward and the base of the stalk is distorted. Right lateral view.

apparently distinguished by behavioral responses rather than by specific optic or olfactory stimuli. The courting male made no distinction between the sexes and tried to court any member of its species with which it came into contact. The salamander being approached by a courting male, however, displayed specific responses. Aggressive behavior invariably developed between males but never between a male and a female. Although no definite territories were established by the males, the aggressive behavior did serve to disperse the males over the available area and thereby increased the probability of a male encountering a female.

If the aggressive reactions of one male toward another male is the method by which sex recognition takes place, the relative infrequency of this behavior in *P. j. metcalfi* may explain the homosexual courtships reported in that species. On two occasions (Organ, *op. cit.*), *P. j. metcalfi* males engaged in tail-straddling walks with other males, and in one of these cases, a spermatophore was

actually deposited. Homosexual courtship in *P. glutinosus* never progressed as far as tail-straddling before one male attacked the other.

Summary

Recently captured *Plethodon glutinosus* in the Mount Rogers-Whitetop mountain area of Virginia engaged in courtship activity throughout the month of September, 1958.

In most details, the courtship pattern of *P. glutinosus* is similar to that of *Plethodon jordani metcalfi*. The pattern differs in the earlier stages in that the male in the former species uses his mouth to grasp the body or tail of the female. In the tail-straddling stage of courtship the *P. glutinosus* male bends his body into a tight lateral circle in an effort to brush his mental gland across the snout of the female. This behavior was relatively infrequent in the tail-straddling stage of *P. j. metcalfi* courtship.

The spermatophore of *P. glutinosus* is similar to that of *P. j. metcalfi* but is more compressed laterally, has a smaller anterior lip on the cap, and has a characteristic mound of jelly on the stalk immediately behind the posterior border of the cap.

The aggressive reaction of males towards courting males is suggested as the method by which the sexes are distinguished in *P. glutinosus* during the courting season. This aggressive behavior between males tends to disperse the males over the available area and increases the probability of encountering a female.

Acknowledgments

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Observations on Breeding and Development of the Surinam Toad, *Pipa pipa*

George B. Rabb and Robert Snedigar

THE reproductive habits of the Surinam toad, which involve development of the young in pockets of the mother's back, have been long renowned but little investigated. The following miscellaneous observational data indicate that the breeding biology of *Pipa pipa* deserves more thorough study, particularly on aspects of hormonal control, metabolism, and behavior.

In the spring of 1958 six adult Surinam toads (snout-vent lengths 120 to 150 mm.) were received at the Chicago Zoological Park from Tarpon Springs Zoo in Florida. They were collected near Leticia, Colombia, in the upper Amazon river basin. The animals were kept in a large aquarium at temperatures of 70–80°F and fed with strips of beef muscle and liver. In the fall of 1958 the only male of

the group began calling. The call consists of metallic clicking noises normally produced at the rate of four per second for periods of 10 to 20 seconds. This male has responded to tapping on its tank by clicking, but has called spontaneously only during the fall and winter, usually early in the morning and again in mid-afternoon.

On the morning of 29 January 1959 the male was found in inguinal amplexus with one of the three smaller females. Clasping continued throughout the day, during which time a sharply demarked area of the female's back gradually swelled into a puffy condition. The swollen area was bounded anteriorly by the wrinkling fold of skin between the arms, and elsewhere by the more lateral pair of epidermal sense organ lines. The lips of her vent also increased in size, presumably through engorgement of cloacal lymph spaces similar to those of *Rana* (cf. Kerr, 1939).

Other reports (Sclater, 1895; Bartlett, 1896) have mentioned a long period of clasping, and one of us (Snedigar) witnessed a partially successful induced breeding in the laboratory of G. K. Noble that likewise featured the skin build-up during long amplexus. The tumid skin area of a breeding female of *Pipa carvalhoi* is well illustrated in the papers of Carvalho (1939: figs. 12 a, b) and Myers and Carvalho (1945: fig. 4).

Unfortunately we did not see the actual deposition of eggs. Bartlett (1896) reported that an evagination of the cloaca is used to conduct the eggs onto the female's back. The figure he furnished of this "ovipositor" was drawn from a specimen that had died while laying, and the structure illustrated was probably pathological. Barlett's specimen is not extant, although it was sent to Boulenger for examination (Sclater, 1896). We wish to thank Alice G. C. Grandison, who kindly searched for it at the British Museum and the Zoological Society of London.

Possibly the normal oviposition Bartlett recorded involved use of the enlarged lips of the vent (fig. 1a). On two occasions we observed a rapid pushing out and up of the lips and perhaps part of the internal cloacal walls by the larger females.

On the morning of 30 January there were 76 eggs adhering to the puffy and vascular skin, some with one-fourth of their diameters beneath the level of surrounding skin. Twenty other eggs were loose in the aquarium. The total of 96 eggs falls within the often cited range of 40–114, figures that originated with Wyman (1854).

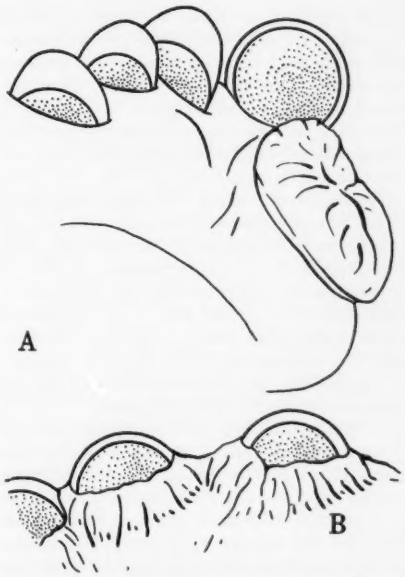

Fig. 1.—Back of *Pipa pipa* shortly after oviposition. A, lateral view of body to show displaced egg membranes and swollen lips of vent, second day; egg directly above vent was eventually lost. B, swelling of skin around eggs, first day. Drawn from 16 mm. motion picture film.

During the first day the eggs on the back sank further into the skin and by evening most were halfway in. The skin appeared to swell up around the eggs, particularly the peripheral ones (fig. 1b). Two days later the yolks of most of the eggs were beneath the skin level, only parts of jelly layers and outer membranes projecting above. The membranes were strongly displaced outwards in many cases (fig. 1a), suggesting that rapid dissolution of the egg membrane occurs where it is enveloped by the skin. In the first six days eight eggs were known to have been lost from the back, apparently having been crowded out as others sank farther in. The outer membranes became nearly level with the skin surface on day 10. We never saw any indication that the covering of a pocket was other than the outer membrane. Noble (1927:71) also arrived at this conclusion after sectioning the tissue. Most of the coverings were lost by the end of the second month, although under natural conditions many coverings of a brood apparently persist until emergence.

The eggs when first observed appeared pearly white. Closer examination showed only a small area of each free of thinly distributed

dark pigment. By the first evening a slight furrow was seen at the animal pole in most of the eggs. No further close observations were possible because debris collected on the pocket coverings. Some loose eggs were kept for a few days but all were attacked by mold. In those kept six days, cleavages were few and superficial.

Yolk diameters of 15 loose eggs from one to four days old averaged 6.0 mm., the outside diameters being 0.4 to 0.6 mm. greater. Average weight of two first day eggs was 0.14 g.

While most of the course of development was obscured, we did note that embryos in four pockets had eyes on day 27. They rotated in response to bright light at this time.

On day 60 a hand was sticking out from one pocket and on the following day this young was "aborted". Two more young were lost in the next three days. The skin shedding that these young and the mother were undergoing at the time may have precipitated the losses. The mother's shedding was probably responsible for the loss of most of the pocket covers.

The young were noticeably active from then on, but it was not until day 77 that living young emerged. The only previously known incubation period, 82 days, seems to stem from the report of Fermin (1765). The sequence of emergence was: day 77, three; 90, one; 119, one; 120, one; 134, one; 135, four; 135–136, nine. Of these 20 live young, three (including the only grossly abnormal one) died within 10 days after emerging. Partial shedding by the female took place at the onset of the last emergences (day 134).

The three young aborted on days 61–63 had substantial amounts of yolk in the abdominal cavities. One of these did not have its jaw flaps developed. Table I provides a comparison of measurements of the only intact aborted specimen, five normal young one day old, and an abnormal specimen with much foreshortened head region and mere indications of jaw flaps. Measurements were made of the minimum body width, maximum width from one jaw flap tip to the other, interocular width at centers of eyes, and length of longest finger.

TABLE I

MEASUREMENTS (IN MM.) OF VARIOUS YOUNG *PIPA* AT EMERGENCE

	Abortion	Average of 5 Normals	Abnormal
Day of emergence	60	77, 136	136
Snout-vent length	16.0	18.0	13.0
Body width	10.0	9.2	9.7
Jaw flap head width	5.8	8.0	4.6
Interocular width	3.8	4.2	3.2
Finger length	2.7	3.3	2.2

The weight of six normal young at emergence ranged from 0.31 to 0.41 g., and averaged 0.36 g., which is two and one-half times the weight of an entire egg. Water displacement estimates for two of these young were 0.33 and 0.35 cc. No significant intial weight differences were found between early and late emergers. The young that emerged on day 77 had more than tripled their weights and were approximately one and one-half times larger in all dimensions by day 136.

All young were heavily pigmented on emergence. The dark **T** marking on the venter was present, although not so prominent as in adults because the surrounding area was relatively darker. Concentrations of dorsal pigment into black patches was not noticeable until the young were a week or more old. Terminal bifurcation of the lobes of the finger tips was not seen in any of the young. All other external adult features were present, including metatarsal tubercles, nasal horns, subocular barbels (but only one on each side) and the subrostral filament. Dunn (1948:3) stated that the last is similar to the jaw flaps, but this appears to be true only in very large adults. With growth the single subocular barbel is shifted toward the rostrum and one or two smaller barbels appear in its original position. Whether any of these are homologues of the similar structures in *Xenopus* is not known.

Pigmentless tissue in the form of two rounded spiraling leaves about 2 mm. in diameter protruded from the cloaca of the first aborted young, and also from one of the first three living young, in which its form was that of a collapsed sac. Blood could be seen coursing through vessels in the transparent tissue of the sac, which diminished and disappeared within a few days. This structure was also found well developed in one, and present in other, preserved young of a Surinam toad in the collection of the American Museum of Natural History. It is probably the "feathery tail" reported by R. R. Moses for all young in an emergence of fifty (Deckert, 1917), since remains of the true tail are rather dark and of firm dimensions in *Pipa*, as in most other frogs. We suggest that the sac tissue probably

serves as a pseudoplacenta or respiratory organ for the pouched young, particularly after the tadpole tail is nearly resorbed. Possibly the thin jaw flaps also serve in this capacity, since they are well vascularized and relatively large in newly emerged young.

Only five of the live emergences were observed. In each instance, after placing head and parts of one or both arms outside the pouch, the young popped out under its own power and swam away. However, in the case of the last four to hatch the mother appeared to be imparting a stimulus for emergence through pressure that gradually forced the backs of one or two, or all four simultaneously, out of the pouches for periods up to two or three minutes. The mechanism for this pressure is not obvious: the pouch walls are merely thin, highly vascularized skin (Klinckowström, 1894; Noble, 1927). Possibly the lungs and *musculus pulmonum proprius* (Beddard, 1895) play a part in the phenomenon.

During the last month of incubation the young were fed *Tubifex*. A mass of worms was dropped on the female's back and parts of the mass were snatched into the pouches and apparently engulfed, to judge from movements of the skin (feeding usually involves a backward thrust or recoil of the whole body). We also believe pouched young snapped *Cyclops* swimming close to pouch openings, but we have no photographic documentation.

The first young to emerge were feeding upon *Cyclops* by their second day, either sweeping the crustaceans in after contact or sometimes just snapping. The lochetic and resting posture was the same as in adults, but active scooping while swimming at the surface or bottom, as practiced by adults, was not observed until the young were more than a month old.

In four of five emergences watched the young swam readily and directly to the surface of the water, which was about 28 cm. deep. The other one went momentarily beneath the mother before surfacing. Swimming, or rather diving was obviously hampered by buoyancy and usually the first two days were spent floating on the surface with occasional dives and rests on the bottom. Timing of five young within 12 hours of their emergence showed that about 5/6 of the time they were at the surface of the water. Nineteen measurements of resting on the bottom gave an average period of 4.8 minutes (range 0.5–17 min.). In contrast, adults generally go up for air about twice an hour. To test whether the young had to learn by practice how to stay down, we captured two as they first came to the surface and kept them in water no deeper than their body lengths. After 72 hours, when their co-emergers were able to navigate the depths of their tank with ease these two were placed for 30 minutes in water 20 cm. deep. They made several attempts to dive but were unable to swim much more than 3 cm. beneath the surface. When they were tested 24 hours later, they were able to negotiate the 20 cm. depth and to remain on the bottom for short periods.

Puzzling was the apparent recognition of young by the mother as non-food items. One of the first three to emerge spent much of its bottom-resting time of the first day beneath the mother. This occasioned swimming in front of her and touching her arms and hands —a fatal maneuver for food animals. At the time the later young emerged there were live guppies (*Lebistes reticulatus*) of various sizes in the acquarium. When one of these fish was unwary enough to contact the mother's outstretched hand, she swept it into her mouth instantâneously, but she did not engulf young *Pipa* that touched her hands. We presume that the recognition is visual, and perhaps under natural conditions in dark or murky waters the young are not so fortunate.

In a group of small young (25 mm. snout-vent length) received in the spring of 1958, disparities in size became very obvious as the group was raised. Size disparities are also developing in the group that emerged on days 134–36, and may indicate an inhibition effect like those reported for *Rana* tadpoles and fish (Rose, 1959).

We made several attempts to induce mating between the male and the other females, which seemed ripe in February, by means of injections of whole *Rana pipiens* pituitary glands and again by use of commercial chorionic gonadotropin hormone preparations. Females began quivering when touched after injection of one or two pituitaries or 0.9–1.0 cc. of the hormone. Injection of the male with two pituitaries did lead to two tentative clasps of five and fifteen minutes duration, but nothing else. Injections also appeared to increase his calling rate for a few days and to cause darkening of his skin.

Summary

Build-up of a sharply demarked area of the female's back accompanies a day-long amplexus preceding oviposition in *Pipa pipa*. Pouch formation results from gradual sinking of an egg into the proliferating skin. The

cover of a pouch consists solely of exposed egg membrane. The incubation period may vary, in this case from 77 to 136 days, with 20 per cent survival from 96 eggs. Emerging young weigh more than twice as much as an entire egg. Young past the tadpole stage have a membranous structure protruding from the cloaca that may be used as an accessory respiratory organ, and perhaps the jaw flaps also aid in this respect. Emergence and late abortions may be related to skin shedding by the mother and/or young. The mother exerts pressure that may partly eject abortions and stimulate live young to emerge under their own power. Advanced young feed while in the pouches if given opportunity to do so. The mother appears to recognize the young as non-food items. These findings suggest features of hormonal control, metabolism, and behavior worth investigation.

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Herpetological Notes

THE COURTSHIP AND EGG MASS OF *AMBYSTOMA GRACILE* AND *AMBYSTOMA MACRODACTYLUM*.—On January 19, 1959, shortly after the snow and freezing weather had abated, twelve *Ambystoma macrodactylum* were captured in a pond in Spanaway, Pierce Co., Washington, and six others were collected up to 300 feet from the pond. All of the aquatic individuals were taken under a single small log in the middle of the shallow pond, and were in the process of courting (water temperature was 6.0°C.). These animals continued courtship in the laboratory (also 6.0°C.) and began to deposit eggs the next day. Eggs deposited in the laboratory and in the field were either dropped singly or in loose tenuous masses of up to fifteen eggs. The egg masses were seldom attached to vegetation but rather were most often deposited directly on the substratum. The egg masses of this species contrast greatly to those of *A. gracile* which are firm, containing a relatively large number of eggs, and are attached to vegetation.

On February 4, 1959, a courting pair, consisting of a neotenic female and an adult male, and a single adult male *Ambystoma gracile* were collected at the same Spanaway pond (water 4.5°C.). Several egg masses of this species were also observed attached to vegetation. These were probably deposited by neotenic females judging from the relatively low numbers of eggs (75–80). For several weeks only adult males and neotenic females were captured (always at night) in the pond. Later, when large egg masses with several hundred eggs were found, metamorphosed females were also collected. Thus, breeding prob-

ably begins with neotenic pairs, then with mixed neotenic and metamorphosed pairs, and finally with metamorphosed pairs.

The courtship of *Ambystoma gracile* has not been described in the literature to date. This phenomenon was twice observed by the writer in the field and once in the laboratory. A courting pair (metamorphosed male and neotenic female) was observed in an open pond at Spanaway, Pierce Co., Washington, in about 15 inches of water at 4.5°C. on a substratum fairly free of vegetation. The pair continued to court in a plastic field bucket for about one hour. A second observation was made of a metamorphosed pair in the laboratory when a female, collected by Mr. Jerry Olson from a rodent burrow about 150 feet from the Spanaway pond, was placed with several male specimens. A third brief observation of clasping was observed at a Fircrest, Pierce Co., Washington, pond in water of 6.0°C. (not 60.°C as given by Slater, *Copeia 1936(4):234*; or 60.°F. as "corrected" by Stebbins, Amphibians of Western North America, p. 34, 1951).

The male about to begin breeding activities may approach the female from either side of the body or tail, or from behind the tail. In any event the male slowly begins to straddle the female's body and then suddenly moves forward, clasping her behind the forelegs with his hind legs. The hind legs of the male are somewhat longer and the feet broader than those of the female, and are well suited for such clasping. If not ready for breeding, the female becomes quite active and with a few powerful strokes of her tail swims forward and through the clasping limbs of the male. Receptive females are very passive when clasped by a male. The cloaca of a non-breeding female was observed to become somewhat larger over a span of one day, before she entered a breeding state.

After clasping the female the male swims with her, dragging her around and often bumping her on the substratum or into sticks and other debris. At times, the male elects not to swim, but merely rests on the substratum with the female firmly clasped. Whether stationary or swimming the male moves its tail in a locomotor fashion at various rates of speed. Periodically the male will hold its tail straight and lash it back and forth, bending only at the base of the tail. Such activity results in rubbing the cloaca across the back of the female. This manipulation causes the male's cloaca to swell noticeably and finally causes the lips of the cloaca to spread far apart, greatly exposing the inner surfaces. These surfaces soon become very red and are presumably engorged with blood. After a few to many minutes of such activity the male may dismount and press his engorged cloacal to the substrate in an attempt to deposit a spermatophore. Alternate clasping and dismounting may occur many times in quick succession at this point. Pectoral clasping is soon ignored in part for a new activity which becomes a common part of the final courting act. At this point the male strides over the female (anterior to posterior) and allows his cloaca to drag along her back and finally over the sharp dorsal edge of her tail. Here the male stops his progress, clasps the female's tail with his hind limbs, and forces the dorsal edge of her tail deeply between his cloacal folds by a series of contractions of his hind limbs. This activity is generally followed by the deposition of a spermatophore on the substratum or other objects. Tail clasping, and weak attempts at pectoral clasping may now follow many times in quick succession. Although the female was seen several times to move and press her cloaca to the substrate where the male had just attempted to deposit a spermatophore, the actual spermatophore transfer was not observed; though a successful transfer was evidenced by the fact that fertile eggs were deposited after four days time. The movements of the female suggest that the transfer is perfected in the act of moving over site of deposition, pressing the wide-spread cloaca to the substrate and then closing the lips over the spermatophore.

The courtship of *A. gracile* differs greatly from *A. macrodactylum*, a species which occurs in sympatry in Washington. Slater (*Copeia 1936(4): 234*) records that the male *macrodactylum* clasps the female behind her forelimbs and gives "short shakes." Three courting pairs were observed in the laboratory by the present writer. In this species the male clasps the female pectorally with his front legs, in contrast to *gracile*. The male thus either swims or walks with the female, and with violent swimming action often succeeds in shaking the female. The male also rubs the snout of the female with the undersurface of his chin. Cloacal manipulation may be achieved as the male's body passes from side to side above the female. Spermatophore transfer was not observed.

Snyder (*Copeia 1956(1):41–50*) describes the egg masses of neotenic individuals of *A. gracile* as being greatly different from those of metamorphosed individuals. He states (p. 44) that masses were "without exception ... of a loose tenuous consistency, not firm as in the case of the adult ..." He continues to say that "A few bunches were attached to grass stems, but most lay free on the bottom." The evidence for these statements and the identification of the eggs is found in the 1) collection of large quantities of such

eggs (50 gallons) from a drained pond in which 2) no adult *Ambystoma* were found, but 3) in which 240 larvae, identified as *A. gracile*, were collected during a two day search (which began fully one day after the eggs were collected). Snyder's description of "larval" egg masses (p. 44) agrees with that of Slater (*Copeia 1936(4):235*) and with that of the present writer, but for *Ambystoma macrodactylum* and not for *A. gracile*. Furthermore, Slater gives the only published record of observing a neotenic form of *A. gracile* actually producing an egg mass, but makes no reference to a loose consistency of the egg mass. The present writer has collected two neotenic specimens of *A. gracile* (135 mm. and 165 mm.) which produced egg masses under field temperatures, of 72 and 103 eggs each. The egg masses were firm and indistinguishable from those of adults, except for numbers of eggs, and were attached to vegetation.

It is the writer's experience at the Spanaway pond that *A. macrodactylum* breeds before *A. gracile* and that the adults of both species remain in the pond for only a few days after breeding. It would seem plausible, therefore, that the egg masses attributed to "larval" *A. gracile* by Snyder were actually those of *A. macrodactylum* which subsequently left the pond, either after breeding, or in the interim between draining the Weiss pond and the search for salamanders. In any event, in view of the facts that 1) Snyder's description for *A. gracile* neotenic egg masses is identical with descriptions of adult *A. macrodactylum*, that 2) two positive *A. gracile* neotenic egg mass records published herein are indistinguishable from those of adults, that 3) *A. macrodactylum* deposit eggs earlier than *A. gracile* and both leave the pond shortly thereafter, and that 4) there is a recognized difference in the egg masses of the two ambystomid species, the present writer can find no ground to support the theory that says soft egg masses are produced by neotenic forms and firm masses are produced by adults of *A. gracile*.—JENS W. KNUDSEN, *Department of Biology, Pacific Lutheran College, Parkland, Washington.*

THE SLENDER GLASS LIZARD, *OPHISAURUS ATTENUATUS*, FROM THE PLEISTOCENE (ILLINOIAN GLACIAL) OF OKLAHOMA.—Among the succession of warm and cool faunas recovered from Pleistocene deposits of the southern Great Plains, the fossil remains of lizards have been previously identified only in those faunas which are correlated with interglacial stages (Etheridge, *Copeia 1958(2):94–101*). A single dentary of an unidentified species of *Eumeces* has now been recovered from the Cudahy fauna (Kansan Glacial?) of southwestern Kansas, and a single vertebra of *Ophisaurus* from the Doby Springs local fauna (Illinoian Glacial) of northwestern Oklahoma. These two fossils represent the only lizards yet obtained from Glacial deposits in this area.

The single caudal vertebra of *Ophisaurus* was recovered from the Doby Springs lake beds, located in the southwestern quarter of section 10, T. 27 N., R. 24 W., Harper County, Oklahoma. The Doby Springs local fauna is assigned to the third glacial interval (Illinoian) by Stephens (*unpublished thesis, University of Michigan*, 1959). The specimen was obtained by Dr. Claude Hibbard during the summer of 1958, and is now No. 40600 in the collection of the University of Michigan Museum of Paleontology.

The fossil vertebra is from the anaterior part of the autotomic series of caudal vertebrae. In vertebrae from this region the ratio of length to width of the centrum in *ventralis* is about 2.2, in *attenuatus* about 2.6, and in the fossil 2.14. The ratio of length of the centrum to its anterior segment in *ventralis* is about 3.7, in *attenuatus* about 3.5, and in the fossil 3.27. The ratio of the length of the centrum to the width across the postzygapophyses in *ventralis* is about 2.2, in *attenuatus* about 1.1, and in the fossil 1.02. The angle of the posterior edge of the neural spine is somewhat less in the caudal vertebrae than in the body vertebrae. The figures given for this angle by Auffenberg (*Herpetologica 11: 133–6*, 1955) are therefore not applicable to caudal vertebrae. This angle in the caudal vertebrae of the anterior autotomic series is about 60° in *ventralis*, about 55° in *attenuatus*, and is 55° in the fossil. Measurements of the fossil, taken with an ocular micrometer, are as follows: total length of the centrum including the articular condyle, 4.31 mm.; narrowest width of the centrum, 1.58 mm.; length of the part of the centrum anterior to the plane of fracture, 1.22 mm.; and width across the postzygapophyses, 3.30 mm. In its meristic characters, the fossil vertebra shows closest correspondence with vertebrae from a corresponding region of the tail of *attenuatus*.

The anterior autotomic caudal vertebrae of *attenuatus* may be distinguished from those of *ventralis* and *compressus* by other features. The anterior border of the transverse processes form nearly a right angle with the longitudinal axis of the vertebra in *attenuatus*, whereas in *ventralis* and *compressus* the processes are directed forward. In addition, the processes are somewhat stouter and wider at their bases in *attenuatus* than in *ventralis* or *compressus*. In these features the fossil is identical with *attenuatus*. The dimensions of the fossil are slightly

less than those of an adult *attenuatus* from Kansas.

The occurrence of *Ophisaurus attenuatus* in deposits of the third glacial interval of northwestern Oklahoma is of considerable interest with respect to the origin and dispersal of the species of glass lizards. According to Stephens (*op. cit.*) the mammalian fauna of Doby Springs deposits suggest habitat requirements similar to the conditions now found in southeastern North Dakota. On the basis of this fauna (34 species of mammals), and the alternation of silts and clays, Stephens concluded that "... a small lake existed around which there were rich meadows and some trees and shrubs. Farther away from the lake there were some well drained upland prairies. The average annual temperature was probably around 42°F., with about 25 inches of precipitation per year, of which 75 per cent fell during the summer months". The coolness of the Illinoian climate of western Oklahoma is also indicated by the fish identified from the Doby Springs and other Illinoian deposits in the area (Smith, *Copeia 1954(4):282–289*; Smith, *Copeia, 1958(3):176–180*).

Ophisaurus attenuatus does not now occur at the Doby Springs locality; the western limit of its range is some 50 miles to the east.

McConkey (*Amer. Midl. Nat. 51(1):133–171*, 1954) has postulated a sequence of events in the origin and dispersal of the species of *Ophisaurus* with respect to the glacial and interglacial intervals of the Pleistocene. He considers that the swollen rivers of interglacial times constituted a barrier to the dispersal of burrowing forms such as glass lizards, and offers the hypothesis that most migrations during the Pleistocene took place during glacial intervals along the Gulf Coast. McConkey further suggests that during the third glacial, "... since the southern coastal route was not very extensive and the cold climate conditions probably extended far down the Mississippi valley, it may be concluded that the dispersal into southeastern United States was not favored at this time. Consequently, differentiation of the eastern glass lizards could have continued, eventually producing the species *ventralis* and *attenuatus*." He also considers that the initial separation of the eastern and western segments of the genus, as well as the initial separation of *ventralis* and *compressus* in Florida, first occurred in the preceding interglacial interval (Yarmouth).

Ophisaurus ventralis has been reported from a single Pliocene and several Pleistocene localities in Florida, and *compressus* from a single Pleistocene locality in that state (Auffenberg, *op. cit.*). The Pleistocene localities have not definitely been correlated with particular glacial or interglacial ages; however, it was pointed out that at least one (Haile II, B), from which both *ventralis* and *compressus* were recovered, is earlier than the Sangamon Interglacial or the Illinoian Glacial. Both of the species must have become differentiated during an earlier time since both are clearly separable in this deposit.

The modern range of *Ophisaurus attenuatus* extends as far north as central Wisconsin. The presence of the species in glacial deposits as far north as northwestern Oklahoma suggests that the distribution of this species during Illinoian times may not have been as restricted as McConkey indicates, allowing for its possible continuous distribution along the Gulf Coast, to overlap the ranges of contemporary populations of *Ophisaurus* to the southeast. In any event, the three modern species of glass lizards appear to have been well differentiated at least by the Illinoian Glacial interval, so that geographic isolation at that time need not be postulated as requisite for their maintenance as separate populations.—RICHARD ETHERIDGE. *Division of Reptiles and Amphibians, Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

CALL DISCRIMINATION BY FEMALE FROGS OF THE *HYLA VERSICOLOR* COMPLEX.—Noble and Hassler (*Copeia 1936(1):63–64*) reported the existence of two call-types within the species *Hyla versicolor* from Maryland and suggested that they were best interpreted as geographic races. The presence of the call-types has been reported at various widely separated localities over the species range. Blair (*Amer. Nat. 92:27–51, 1958*) demonstrated the degree of difference objectively by the use of sound spectrograms. Johnson (*Copeia, in press*) found a high degree of genetic incompatibility in reciprocal crosses of the call-types in Texas, and backcrosses are now in progress. He suggested that the two forms were behaving as biological species. Littlejohn and Michaud (*Tex. Jour. Sci. 11:86–92, 1959*) presented experimental data supporting the thesis that anuran calls act as pre-mating isolating mechanisms. The objective of the work reported here is an attempt to determine experimentally whether females can discriminate recorded calls of males of both call-types.

On the evening of April 18, 1959, Ted C. Michaud and M. J. Fouquette, Jr., were collecting frogs and tape-recording their calls in Beaver Bend State Park, Oklahoma. Michaud observed a female *H. versicolor* approach a calling male, which immediately clasped her. The pair was caught and separated, and the male was released. The male was observed until be began calling, at which time the call was recorded. It proved to

be of the fast-trilled type. Both call types were present at the site in a mixed chorus.

The female was placed in an ice-box and returned to the laboratory at The University of Texas the following day. She was kept in the refrigerator at approximately 5.5°C. until the evening of April 20, when she was removed and placed in the water of the discrimination tank (described by Littlejohn and Michaud, *op cit.*) in a small jar. During the next hour or so, while her body temperature equilibrated to that of the tank (18°C.), recordings of calls of *Pseudacris clarki*, *P. nigrita*, and both *H. versicolor* call-types were played at irregular intervals. Thus, there was some "conditioning" but this was not a controlled operation. A tape-loop of each call-type repeated at approximately the normal repetition rate was made from recordings of males taken at the same station. Each of these loops was placed on a recorder and played through a speaker, one at each end of the tank, according to the techniques of Littlejohn and Michaud (*op. cit.*). The only modification of method was that, generally, after each "contact" the sound was turned off and the frog returned to the center of the tank. The calls were then switched to opposite speakers and a new test started.

If a female touched or came within two inches of a speaker, this was scored as a *contact*. When a contact was made, and the frog then moved 12 inches or more from this speaker, and returned to it again, this and any subsequent contacts were also scored. These were termed *secondary* contacts, the initial ones *primary* contacts. The period of time from the release of frogs at the center of the tank until contacts were made and calls exchanged, was referred to as a *trial*.

The speaker through which the fast-trilled call was played is hereafter referred to as the *fast* speaker, the other as the *slow* speaker.

The results follow: Eight primary and three secondary physical contacts to the fast speaker were scored. In addition, on one occasion the calls were switched immediately after a contact, while the frog was still near the speaker. The frog made contact with the near speaker, which now emitted the slow-trilled call, reoriented, and swam the full length of the tank to contact the fast speaker. We did not include these two contacts as primary or secondary. Thus a total of 12 contacts with the fast and one with the slow speaker were scored.

As the frog sat near the center of the tank there was no noticeable response to either call while the two calls were being produced simultaneously. But at the first call of the fast-trilled type that was out of phase with the other, she immediately oriented toward the fast speaker by turning her head or, more often, her entire body toward it. Thereafter each fast call which was out of phase with the slow calls invoked positive response so that the female swam toward it and eventually made contact. Usually less than one minute elapsed from the time the female was released in the center of the tank until she contacted the speaker.

At the end of this experiment several male frogs were placed in the tank, and one fast-triller began to call. The female responded in the same way that she had done with recorded calls, and amplexus occurred.

Six amplexed *H. versicolor* females of a number collected in a pure fast-trilled population, one mile east of Palmetto Park, Gonzales County, Texas, on May 3, 1959, were also tested with the same apparatus on the night of collection. Three of the females were released at the center of the tank, and within 12 minutes the first contact with a speaker was observed. Three trials were made in which 8 primary and two secondary contacts were scored with the fast speaker, 7 of which were direct physical contacts. During the first trial two females came together about 1 foot from the fast speaker and assumed a loose amplexus that persisted for about three minutes. The frogs were then replaced by the three others and during two trials 7 primary and 2 secondary contacts were scored with the fast speaker, of which 8 were direct physical contacts. Thus, the six females made a total of 15 primary and 4 secondary contacts with this speaker. No orientation was observed toward the slow speaker. All 6 females made contacts with the fast speaker. As with the first frog tested, response to the fast call was elicited only when the slow call did not overlap it. On the following evening, 8 other females of the lot collected near Palmetto Park, which had been stored under refrigeration for about 24 hours, were tested. During 80 minutes of observation none of these showed clear response to the calls, and all movement appeared to be more or less at random.

Two amplexing pairs of *versicolor*-complex frogs were taken in Buescher State Park, Texas, on the evening of May 24, 1959. Several males of both call-types were calling around the pool where the pairs were collected. One pair was taken from the water and the other about seven feet from the ground on the trunk of a small juniper. Both pairs were placed in the same jar, and both broke amplexus, so that the original partners were not determinable.

The frogs were returned to the laboratory, and the females were placed in the center of the discrimination tank. The same tape-loops were used as in the previous experiments. Within two minutes one female had contacted the slow

speaker, and in seven the other had contacted the fast speaker. In all, three contacts (two primary and one secondary) to the slow speaker were scored for one female, two primary contacts to the fast speaker for the other. The experiments were terminated at the end of 12 minutes in order to use these females in making crosses. In spite of the small number of contacts scored, there was no doubt as to the discrimination on the part of these females; they were highly responsive and each oriented to only one call type.

The two males, which had been placed in separate jars, began calling during the experiments, and it was found that one was a slow, and the other a fast triller.

It appears conclusive that females of the fast-trilling species of the *versicolor*-complex can readily discriminate between the calls of their own and those of the slow-trilling species. There are also indications that a similar specificity is present in females of the slow-trilling species. The females are attracted to the calls of their own species and can localize the sound readily at a distance of six feet. Since the presentation of a single clear call elicited positive response, it seems that the call repetition rate is not critical. The only other feature of the mating calls that differs markedly is the trill rate. The fast triller has a trill rate about twice that of the slow triller (Table 1). Thus discrimination may depend chiefly on the difference in this component.

Of the 32 contacts scored for the 7 confirmed fast-trilling species females, only one was with the slow speaker. This contact occured directly after reversing the calls without returning the frog to the center of the tank.

These results further substantiate the contention of Johnson (*op. cit.*) that the two call types represent valid biological species. It is also of interest to note the potential of call-discrimination testing as a method of identifying ripe females of cryptic species complexes collected in sympatric breeding assemblages.

From our experience in discrimination experiments, it appears that females will respond to the male call only when they are at a reproductive peak. Females collected immediately after amplexus seem to be best, presumably because they have most recently reached this peak. Such females have probably not begun ovulation, and usually may be kept refrigerated for some time before they are tested, e.g. the Oklahoma female. More often obtained are females that have been in amplexus for an undetermined period of time, and these may have begun to ovulate. These should be tested on the night of collection, since they may often become stale and show at the most poor response, as in the Palmetto frogs tested on the night after collection. Females not yet ready to ovulate or those that have already oviposited have never shown any response in experiments at this laboratory.

TABLE 1

PHYSICAL CHARACTERISTICS (OBTAINED BY SOUND SPECTROGRAPH ANALYSIS) OF THE TWO CALL-TYPES OF THE *Hyla versicolor* COMPLEX USED IN THE DISCRIMINATION TRIALS. THESE WERE RECORDED AT BEAVER BEND STATE PARK, OKLAHOMA, ON APRIL 18, 1959; AIR TEMPERATURE 18°C., WATER, 21°C.

Call-type	Duration (seconds)	Number of notes	Trill rate (notes/second)	Dominant frequency (cycles/second)	Call repetition rate (call/minutes)
Fast triller	1.09	43	39	2500	8.7
Slow triller	1.17	23	20	2200	17.3

M. J. Littlejohn gratefully acknowledges receipt of a Hackett Studentship from the University of Western Australia and a Fulbright Travel Grant during the period in which this research was undertaken. We also acknowledge the assistance of W. F. Blair and George Drewry, who participated in some of the discrimination experiments.—MURRAY J. LITTLEJOHN, *present address: Department of Zoology, University of Melbourne, Victoria, Australia.*, M. J. FOUQUETTE JR., and CLIFFORD JOHNSON, *Department of Zoology, The University of Texas, Austin, Texas.*

NOTES ON COLLECTING IN NORTH CAROLINA PINE PLANTATIONS.—Seven specimens of the Scarlet Kingsnake (*Lampropeltis doliata doliata*), three young Corn Snakes (*Elaphe guttata guttata*), two Common Chain Kingsnakes (*Lampropeltis getulus getulus*), numerous Rough Earth Snakes (*Haldea striatula*), numerous Southern Ringneck Snakes (*Diadophis punctatus punctatus*), and two of the rarer Yellow Lipped Snakes (*Rhadinaea flavilata*) were obtained in a week's collecting trip in Brunswick Co., North Carolina. All were collected within a twenty mile radius of the town of Shallotte.

There are many tree farms in this area which raise pine trees for the paper pulp industry. Their systematic way of cutting and replanting trees has resulted in many stumps standing in all stages of decay. All of the specimens were obtained by tearing away the bark from these stumps with a stevedor's hook. All were discovered just under the bark, but did not hesitate to burrow into the rotting wood upon discovery.

The seven Scarlet Kingsnakes are of particular interest because of the rarity of the species and the lack of it in most scientific collections. Four of the Scarlet Kingsnakes were obtained on April 8, 1959, between the hours of 9:00 AM and 4:30

PM. A light rain had fallen the previous evening, leaving the wood quite damp. The average temperature for the day was 70°F. Three others were obtained on April 10, an overcast day with intermittent showers during the day. Collecting hours and temperature were identical to those on the 8th.

Surprisingly, all of the snakes were discovered in the taller stumps only, at least three feet above the ground. One Kingsnake was collected in a stump a full five feet above the ground. The numerous low stumps yielded nothing. All of the Scarlet Kingsnakes and many of the other specimens were preparing to shed their skins, having reached the "milky" stage in the process.

The abundance of snakes in sterile pine plantations, an area usually shunned by collectors, suggests that further investigations might well be rewarding.—LAURENCE B. WHITE, JR. *Education Department, Museum of Science, Science Park, Boston, Massachusetts.*

A DESCRIPTION OF A SIX-LEGGED BULLFROG, *RANA CATESBEIANA*.—Reports of anomalies in *Rana aurora* were made by Cunningham (*Herpetologica 11:149* 1955) who reported a frog with only one front leg and one with three hind legs. Another interesting, naturally occurring, abnormal *Rana* with two complete pairs of hind limbs has come to my attention and is described herein. A young bullfrog having two pairs of hind limbs was brought to my laboratory by Mr. Garry Vannausdle of South Bound Brook, New Jersey, who collected the specimen. It was captured from the Delaware-Raritan Canal on August 4, 1958, and it lived in an aquarium in my office till it died of unknown causes on August 22. The specimen was 48 mm. in snout-vent length and had probably metamorphosed sometime during the summer of 1958. There was no evidence of the larval tail.

Examination indicated that there was a doubling of the pelvic girdle and the pelvic appendages with all elements present although some were of reduced size Both legs of the right pair (Fig. 1, legs III, IV) were functional and they would extend and flex simultaneously. The right member of the left pair of legs (leg II) was not functional and was dragged somewhat in the fashion of a tail. The left member of the left pair (leg I) was well developed and functioned synchronously with the members of the right pair. A cloaca was present in the normal position in the left pair of appendages, but none was associated with the right side.

As seen in Figure 1, the skeletal elements of the pelvic appendages of both pairs of hind limbs were normal. There were two puboischiac plates and each had a pair of ilia associated with it. The right girdle was tilted outwards at 45° from horizontal, while the left girdle is tilted outwards about 10–15°. It was also seen that the left ilium of the left pair and the right ilium of the right pair were normal, whereas the medial ilia of the two pairs were shortened and fused at their tips. These ilia extended dorsally at an angle and the fused points formed a noticeable bump on the dorsal surface of the frog, posterior and to the right of the tip of the single urostyle. At the time of capture the skin was bruised and irritated above this bone, but it healed under laboratory care. The single urostyle was curved toward the midline of the left girdle. Evidence around the tip of the urostyle indicated bruises and bleeding in the muscles and below the skin.

The musculature of the pelvic limbs was normal and varied only in the extent of development. Limbs I and IV were best developed while Limb II was quite small and poorly developed. On the left pelvic girdle, the M. pyriformis was normal, whereas, on the right girdle the M. pyriformis was much reduced and originated on the dorsal surface of the ischium rather than on the tip of a urostyle. The M. gluteus (external iliac) was normal on limbs I and IV while it was considerably reduced and shortened on the similarly reduced ilia of limbs II and III. Instead of extending between the ilia of a girdle and the urostyle, the M. coccygeoiliacus originated on the left ilium of the left pair and the right ilium of the right pair and inserted on the one urostyle. The M. rectus abdominus inserted on a tendinous plate connecting the ischia of right and left pairs.

In the venous system the single ventral abdominal vein was formed by the fusion of right and left pelvic veins which were, in turn, formed by the femoral vein of limbs IV and I. The sciatic veins of these two legs emptied directly into the right and left renal portal veins, respectively. Both sciatic and femoral veins of limb II and limb III joined separately, but in close proximity, into the right renal portal vein. Therefore, limb I was drained by the left renal portal and all other sciatic or femoral veins of the other three legs emptied into the right renal portal.

The arterial arrangement was similar. The aorta divided into a left iliac artery that supplied only leg I. The right iliac divided first (inside the pelvic girdle) into a branch supplying limb II. Then just distal of the pelvic girdle the iliac divided into two sciatic arteries serving the two members of the right pair of legs (III and IV).

The sciatic nerve trunk followed the arterial system closely. The left sciatic trunk served limb I; the right trunk divided into one branch serv-

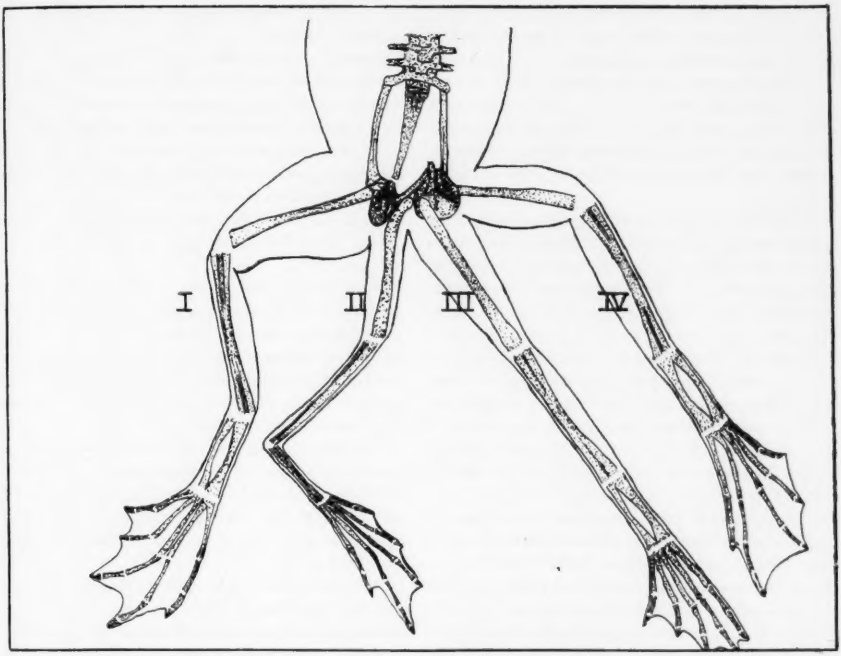

Fig. 1.—Diagramatic drawing of a pelvic structure of *Rana catesbeiana*. General outlines were obtained from a 2.7 × enlargement of an X-ray while details were obtained by dissection. Dorsal view.

ing limb II and then distally it divided into two branches serving the legs of the right pair.

Thus, it appears that there was a doubling of the pelvic girdle and all associated structures. Most probably, the left pelvic girdle (and appendages) was the normal one and the right girdle the additional one, since the left side has the single cloaca and urostyle associated with it. The venous, arterial, and nerve trunks of the right pair of legs fused with the appropriate trunks of limb II and trunks on the right side of the body. In fact, it appears that the trunks of the right pair of legs captured the supply of the right side of the body, for limb II was poorly developed and non-functional.

The cause of this anomaly is unknown, but it is interesting that news releases were recently made about similar anomalies in a population of bullfrogs near Tunica, Mississippi. Dr. McClurkin of Memphis State University has this group of frogs under observation at the present time.—PAUL G. PEARSON, *Rutgers, The State University, New Brunswick, New Jersey.*

THE EGGS AND YOUNG OF *DRYMARCHON CORAIS COUPERI*.—During the past ten years, four clutches of eggs have been deposited by indigo snakes in confinement at the Baltimore Zoo. The data on hatching and observations on the young are presented herewith.

On May 28, 1950, a four-foot specimen from Florida deposited six eggs. These were roughly oval in shape, off-white in color and were covered with small, granular surface accretions. They varied in length from 59.3 to 70.5 mm. and in width from 33.0 to 35.6 mm. The weights varied from 42.0 to 48.5 grams.

These eggs were incubated in damp sawdust. One was opened a month after laying to disclose a three-inch embryo and another spoiled during the course of incubation. Of the four remaining eggs, three hatched on September 10 and the other on the next day. The young varied in total length from 469 to 485 mm.

The hatchlings refused to feed until after the first slough which occurred ten days after hatching. They then began to feed on an average of once a week on young mice, small frogs and other snakes. From the beginning they showed considerable aptitude in handling intractable prey. Active mice were subdued by holding them to the floor of the cage with a coil of the body thrown over them. Young copperheads were invariably seized by the head and that member was

thoroughly chewed until the pit-viper was quite dead before swallowing began. This method of handling potentially dangerous snakes had been noted previously in an adult indigo snake feeding on a large and savage *Natrix*. On one occasion, one of the hatchlings was bitten on top of the head by a young copperhead; there was no reaction other than profuse bleeding from the fang-punctures.

Records of sloughing were kept on three of the snakes over a period of nine months dating from time of hatching. During this period one snake shed six times, the other two shed eight times. Intervals between sheddings varied from 21 to 47 days.

Three more clutches of eggs were laid by a single female, one of a matched pair that was shipped to the Zoo by a Florida dealer in January, 1954. When received, the female measured 5.5 feet, the male a little over 6 feet. At this writing (1959) they have reached lengths of 6.5 and 7.5 feet respectively.

The first set of eggs was deposited on May 14, 1956. No mating activity had been observed. Nine eggs, two of which appeared to be infertile, were laid. The seven apparently good eggs varied in length from 61.2 to 68.9 mm. and in width from 35.0 to 39.5 mm. Their weights were from 52.0 to 64.5 grams. After two weeks of incubation all of these eggs were attacked by mold and spoiled.

The second clutch produced by this pair was laid on May 25, 1957. Again no mating activity was noted. The female interrupted her regular weekly feedings for a period of six weeks before laying, then resumed eating two days after the eggs were laid. This clutch contained eleven eggs which were 56.1 to 68.8 mm. long and 36.4 to 40.1 mm. wide. Weights were from 41 to 57 grams.

During the course of incubation two of these eggs molded. Three eggs hatched over the period August 22–26 and six failed to hatch because of deformities in the emryos. The hatchlings remained in the eggs for 24 to 48 hours after slitting the shells. Their weights at hatching were 38, 43 and 44 grams and one was measured at 432 mm., total length.

Two of these snakes sloughed ten days after hatching; the third died during this period without having shed. Of the two remaining snakes, one died when about three weeks old, the other is still alive. At the end of it's first year of life, this specimen had reached a length of 870 mm. and a weight of 228 grams. During this time it fed regularly once a week on mice and small snakes and sloughed 13 times. The intervals between sheddings varied from 17 to 46 days.

On October 30, 1957 mating between our pair of indigo snakes was noted for the first time. This act occurred again on October 31 and also on January 20, 1958.

On October 31 at 2:40 PM, the male, who was in process of shedding with loose streamers of epidermis hanging from his body, was lying along the length of the female with his body draped over her, part on one side and part on the other. At this time he was rubbing his chin over the female's head and neck. These actions were accompanied by convulsive "twitchings" of the male's body. There was a strong musky odor in the cage at this time.

This preliminary activity continued for about an hour with the female acting, for the most part, in a passive manner. Several times she tried to throw off the male and escape by climbing up the walls of the cage. Once the male interrupted the process to rub his head against the floor in order to remove a piece of loose epidermis.

Finally, at 3:50 PM, the female began to cooperate. She arched the anal region of her body an inch or so off the floor of the cage while the male brought the corresponding part of his body alongside. Insertion of the male's right hemipenis occurred at this time.

The two snakes remained in this position for some 15 minutes. At intervals, convulsive movements would begin in the region of the male's neck and pass, wavelike, posteriorly over his entire body. These movements each lasted about 30 seconds and were repeated six times. The female remained quiet during this stage.

After resting for ten minutes the male resumed the performance described above. During this second performance, however, it was noted that the left hemipenis was inserted in place of the right. When observations were terminated at 5 PM, the snakes were still in coitus.

On January 20, 1958 mating occurred again in the same manner as before. On this date, the female had an open cut about 4 inches long on her neck. Apparently, it was the result of the male biting her during the mating act. Again, on March 11, a similar fresh cut was noted on the female's neck although no mating activity had been observed.

On May 6, 1958 the female deposited 11 eggs. Again there was a period of fasting (nine weeks) before deposition. These eggs measured 56.4 to 74.1 mm. long and 37.1 to 40.6 wide. The weights varied from 50 to 60 grams.

During the incubating period two of these eggs were opened for examination and five succumbed to mold. On August 7 one hatchling emerged from it's egg and the three remaining eggs had one or more longitudinal slits in their shells. When these eggs had not hatched after three days time they were opened to disclose perfectly formed, but

dead, embryos. The cause of death could not be determined.

The single living hatchling measured 443 mm. and weighed 42 grams. It survived for just two months. At first, it refused to feed and was force-fed twice. A week before it's death it voluntarily ate a small snake. The natal skin was shed on the ninth day after hatching and subsequent sheddings took place on September 1 and 17 and on October 1.—FRANK GROVES, *Baltimore Zoo, Druid Hill Park, Baltimore 17, Maryland.*

OBSERVATIONS ON *STERNOTHAERUS ODORATUS* IN MARSHALL COUNTY, INDIANA.—A phenomenon has been noted in numerous specimens of *Sternothaerus odoratus* collected in Marshall County, Indiana. There is a reduction in the opacity of the dorsal laminae of these specimens, revealing the sutures of the underlying bones. This transparency may be due to a reduction in the pigmentation of these shields or a reduction in their thickness. The phenomenon appeared in nearly all of about one hundred specimens of *Sternothaerus odoratus* captured in Lake Maxinkuckee, Marshall County, Indiana, and in a nearby hatchery. This occurrence seems analogous to one of the characteristics of *Kinosternon b. bauri* that helps to distinguish it from *Kinosternon b. palmarum* (Uzzell and Schwartz, *Jour. Elisha Mitchell Sci. Soc. 71:28–35,* 1955).—JAMES G. CUNNINGHAM, *319 Overdale Road, Pittsburgh 21, Pennsylvania.*

PLACENTAL TRANSMISSION OF Na^{22} AND I^{131} IN *NATRIX*.—Anatomical studies have demonstrated the occurrence of both yolk sac and chorio-allantoic placentas in several Australian and European viviparous reptiles (Weekes, *Proc. Zool. Soc. Lond., 625–645,* 1935). Placentation has been less studied in North American forms, although there are descriptions of the placentae of *Thamnophis* (Gibson, *M. A. Thesis, State Univ. of Iowa Library,* 1934), and Xantusia (Heimlich and Heimlich, *Jour. Ent. Zool., 42:5–12,* 1950). Placentation has been reported also in *Storeria, Potamophis(=Haldea), Thamnophis* and apparently *Natrix* (Rahn, *Proc. Soc. Exp. Biol. Med., 40:381–382,* 1939).

The functional role of the reptilian placenta and the nature of maternal-fetal exchanges across the placental barrier remain poorly known. On the basis of anatomical relationships, Weekes (op. cit.) concluded that the placenta has a nutritional function only in forms with reduced yolk and a specialized glandular folded allantoic placenta. She considers the yolk sac placenta to function in water supply, and the chorio-allantoic placenta to be an organ of respiration. Kasturirangen (*Proc. Indian Acad. Sci. B., 34:1–32,* 1951), however, emphasizes that in *Enhydrina* and *Hydrophis* fetal and maternal blood supplies are in very close approximation. He suggests that hemotrophic nutrition could occur under such conditions.

Recently Panigil (*Ann. Sci. Nat. Zool. Biol., 18:569–672,* 1956) has studied maternal-fetal exchanges in the oviviparous lizard *Zootoca.* Experimental evidence indicated that in this species there was limited passage of I^{131}, Na^{22}, and P^{32} from maternal into fetal tissue even though a persistent thin shell membrane separates maternal and fetal membranes.

The purpose of this study has been to investigate the passage of Na^{22} and I^{131}, in placental forms.

Methods.—Pregnant *Natrix sipedon* and *N. cyclopion* were used in the experiments which were conducted in late July and August on near-term animals. At this stage, maternal and fetal tissue

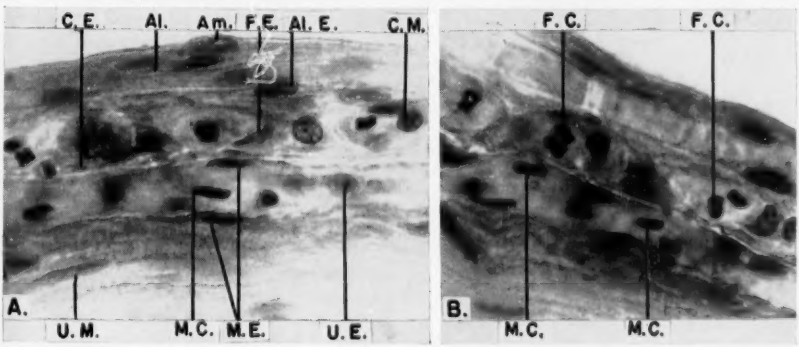

Fig. 1.—A and B sections through placenta of near term *N. sipedon* showing endothelial-endothelial placentation. Allantois (Al); Allantoic endoderm (Al.E); Amnion (Am.); Degenerate chorionic ectoderm (C.E.); Chorionic mesoderm (C.M.); Fetal erythrocyte (F.C.); Fetal endothelium (F.E.); Maternal erythrocyte (M.C.); Maternal endothelium (M.E.); Uterine epithelium (U.E.); and Uterine muscle (U.M.).

are in apposition and a simple chorio-allantoic placenta, apparently of an endothelial-endothelial type, is established (Fig. 1). The finer morphology is very similar to that of the euryplacental region of *Enhydrina* which Kasturirangen (*op. cit.*) has described in detail.

Placental transmission of iodine was studied by injecting intraperitoneally five microcuries of carrier free I^{131}, in the form of NaI^{131}, per 100 gm. wgt. into two *N. sipedon*. These animals were held at 22°C. for 24 hours after injection and then sacrificed. Maternal and fetal thyroids were dissected and stored in one ml. of formalin. The samples consisting of three to five fetal thyroids or the adult thyroids were weighed and then prepared for counting by a micro modification of the alkaline digestion method of Perkinson and Bruner (*Nucleonics, 10:66–67*, 1952). A disc of filter paper was placed on a copper planchet and a 0.2 ml. aliquot of the digestion mixture added. The planchet was dried under an infra-red lamp. Three aliquots were counted from each digestion mixture. The samples were assayed using a nuclear model D-34 mica-end-window tube (1.4 mg./cm.^{2}) connected to a nuclear model 161-A scalar. The counting error was kept within 3% for thyroid and within 10% for liver.

Similarly, carrier free Na^{22} in the form of $Na^{22}Cl$ was injected into five pregnant snakes. Two microcuries/100 gms. was injected into each snake. The tissues used were: maternal hearts and livers, entire fetuses, and pooled fetal livers. The net weights of all samples were recorded. Tissues were ashed as 550°C., and the ash was taken up in dilute nitric acid. Three ml. aliquots were counted using a N.R.D. model B-1602 scalar. The counting error was kept within 3%. All data have been recorded as counts per minute per milligram of wet weight tissue, after correction for background radiation.

Results and discussion.—The results obtained were summarized in Table I. These data show that both Na^{22} and I^{131} transfuse the placental barrier. Accurate estimates of transfer rates cannot be obtained from such data. Probably transfer is more rapid in the placental *Natrix* than in *Zootoca* (Panigil, *op. cit.*). When the ratios of counts per minute per milligram weight of fetal to maternal tissue are compared (Table II) it appears that the differential between fetal and maternal tissue is much less in *Natrix* than in *Zootoca*.

Caution must be used in interpreting these data, since specific maternal organs were used as contrasted to the entire fetus in most cases. The maternal tissues utilized were heart and liver. These vascular tissues would be expected to show higher Na^{22} concentrations than the average for the entire body. Accordingly, the ratios comparing these organs to entire fetuses probably underestimate the transfer and also do not permit determination of equilibrium times. When the data comparing fetal to maternal liver are examined, it is seen that the results from both of the 24 hour animals indicate higher sodium concentration in fetal than in maternal liver. This may be due to greater amounts of fluid in fetal liver and consequently higher levels of dissolved sodium.

Comparable data from both *Natrix* and *Zootoca* (Table II) suggest that equilibrium may be attained very rapidly in *Natrix*. The activity ratios

TABLE I

CONCENTRATION OF ISOTOPES IN MATERNAL AND FETAL TISSUES

Animal	Hours After Injection	Fetal		Maternal	
		Tissue	C/mg./min.	Tissue	C/mg./min.
SODIUM					
N. cyclopion	6	1 fetus	431	heart	13,150
		2 fetuses	572	liver	9,840
		10 livers	203		
N. sipedon	12	2 fetuses	522	heart	31,990
		2 fetuses	485	liver	9,650
N. sipedon	12	1 fetus	915	heart	18,000
		2 fetuses	629	liver	23,800
N. sipedon	24	1 fetus	152	heart	3,390
		1 fetus	190		
		10 livers	24,810	liver	3,390
N. cyclopion	24	1 fetus	260	heart	4,510
		10 livers	8,105	liver	2,580
IODINE					
N. sipedon	24	8 thyroids	350.6	thyroid	1,920
		3 livers	0	liver	1.3
N. sipedon	24	4 thyroids	147.5	thyroid	1,137
		4 thyroids	48.1	liver	0.9
		3 thyroids	82.1		
		3 livers	0		

TABLE II

A COMPARISON OF PLACENTAL TRANSMISSION OF Na^{22} IN *Natrix* AND *Zootoca*

Species	Fetal/Maternal Tissue	Hours After Injection				
		6	8	12	24	30
Natrix	Fetus/heart	1/29		1/63	1/19	
				1/23	1/17	
	Fetus/liver	1/22		1/19	1/19	
				1/30	1/10	
*Zootoca**	Fetus/uterus		1/267		1/30	1/44
	Fetus/blood	1/472	1/533		1/190	1/73

* Data calculated from Panigil (*op. cit.*)

of fetal to maternal tissue from *Natrix* do not show any great change with time after injection, while similar data from *Zootoca* show continued increase of fetal sodium concentration. Placental efficiency in sodium transport in *Natrix* may be comparable to that reported in mammals (Gellhorn, Flexner and Pohl, *Jour. Cell. Comp. Phys., 18:393–399*, 1941).—C. H. Conaway and W. R. Fleming, *Dept. Zoology, Univ. of Missouri, Columbia, Missouri.*

HYBRIDIZATION BETWEEN *HYLA VERSICOLOR* AND *H. FEMORALIS*.—In the summer of 1958 I collected two treefrogs that are believed to be hybrids between *Hyla versicolor* and *H. femoralis*. One of these was obtained on the night of June 4, 1958, about two miles southwest of Wortham, Harrison Co., Mississippi. I was immediately aware of the peculiar call of this individual upon approaching a small mixed chorus including *Hyla versicolor, H. femoralis* and *Acris gryllus*. The call was a short trill resembling that of *versicolor*, but with the rattling, unmusical quality of the call of *femoralis*. The sound was so distinctly different from all other calls heard at that time, that I was able to go directly to the individual producing it. The frog was perched on the trunk of a small oak about six feet above the surface of the water. The chorus was located in an inundated area of second-growth hardwoods. Air temperature at about 10:00 p.m. was 26°C., water temperature 25°C.

The other supposed hybrid was collected in a large mixed chorus on the night of June 22, 1958, 8.4 miles west-northwest of Baxterville, Marion Co., Mississippi. A light rain had been falling all day at this locality. At 9:30 p.m. the air temperature was 24°C., water temperature 25°C. The chorus occupied a grass-margined semi-permanent roadside pond in second growth hardwoods with some young pine mixed in. Males of the following species were calling: *Hyla versicolor, H. femoralis, H. avivoca, H. squirella, H. cinerea, H. gratiosa, Acris gryllus, Bufo quercicus, Rana catesbeiana* and *Gastrophryne carolinensis*. The supposed hybrid was not heard calling at that time, although it had a pigmented throat and was aparently a male.

The two frogs believed to be hybrids were very similar in appearance and both resembled *versicolor* in size and body proportions more so than *femoralis* (Fig. 1). Both had a light subocular spot as in *versicolor*. The dorsum was purplish-gray, a color commonly shown by *femoralis*, but one that I have never seen precisely duplicated by *versicolor*.

One of the supposed hybrids, the last one caught, is still alive (September, 1959). The intensity of its color changes readily, so that in the blanched condition the dorsum has a lavender cast. It is always readily distinguishable from several *versicolor* that are kept in the laboratory for breeding purposes.

On the night of May 3, 1959 a female *H. versicolor* was collected at Tennessee Colony, Anderson Co., Texas. The female was being clasped by a male *versicolor* on a horizontal limb about three feet above the surface of the water of a roadside ditch. Eggs from this female were stripped into separate sperm suspensions prepared from the testes of a male *versicolor* (control) and a male

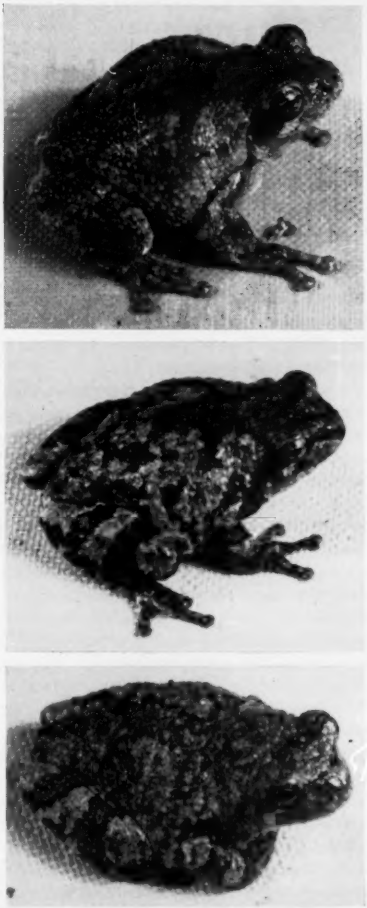

Fig. 1.—Top: Supposed natural hybrid of *Hyla versicolor* × *H. femoralis*, collected near Baxterville, Mississippi; snout-vent length = 46 mm. Center: Artificial female *H. versicolor* × male *H. femoralis* F_1 hybrid; snout-vent length = 35 mm. Bottom: Female *H. versicolor* × male *H. versicolor* F_1 control; snout-vent length = 35 mm.

TABLE I

RESULTS OF CROSSES BETWEEN A FEMALE *Hyla versicolor* FROM ANDERSON CO., TEXAS AND MALES OF THE SPECIES IN THE LEFT-HAND COLUMN

Male	No. of eggs	Hatch (%)	Metamorphosis (%)	Stage reached
Hyla versicolor, (control) Anderson Co., Texas	291	60.1	41.9	Adult
H. femoralis, Harrison Co., Mississippi	299	17.7	16.7	Adult

femoralis. Results of these crosses are summarized in Table I. Although some developmental abnormalities occurred in both groups, the results indicate that the hybrids were less viable than the controls in embryonic development under laboratory conditions. Tadpoles were fed boiled lettuce and the frogs, leafhoppers and mealworms. The controls hatched on the second and third days after fertilization, and metamorphosed from 37 to 120 days after fertilization. Some of the largest controls (Fig. 1) have pigmented throats now (September, 1959), but I have not heard them call.

The hybrids hatched on the second and third days after fertilization, and metamorphosed from 33 to 102 days after fertilization. All of the hybrids that reached metamorphosis (50) are alive at the present time, and there is no indication of post-metamorphic inviability. The largest male hybrids (Fig. 1) have pigmented throats and have been calling occasionally since August 28, 1959, indicating that sexual maturity was attained by some in 116 days from the time of fertilization. The call of the artificial hybrids is a short trill similar to that of the supposed natural hybrid, but with less volume. The artificial hybrids resemble the *versicolor* controls and the natural hybrids in their stout body proportions and in the presence of a light subocular spot. They are like *femoralis* and the natural hybrids in their purplish-gray color. Wartiness of the artificial hybrids is variable, but some have about as many warts as the natural hybrid (Fig. 1). The hidden surfaces of the hind legs of the artificial hybrids are pale yellow as in the controls. These surfaces are yellow-orange in the supposed natural hybrid.

Fertility of the hybrids will be tested by backcrossing them to the parental species at the earliest opportunity, but I shall probably be unable to continue the field investigations. For this reason it seems desirable to present the above information at this time. Frequency of occurrence of natural hybrids and of cross-matings between these two species in nature would be of interest.

I am indebted to Mr. Dexter Betts for the photographs and to the National Science Foundation (Grant No. G-5494) for financial support in the course of this work.—WILLIAM F. PYBURN, *Department of Biology, Arlington State College, Arlington, Texas.*

PHYSIOGRAPHIC PROVINCES AND DISTRIBUTION OF SOME REPTILES AND AMPHIBIANS IN JOHNSON COUNTY, INDIANA.—Johnson County is a critical area as regards the distribution of Indiana reptiles and amphibians for it contains portions of three physiographic provinces as outlined for Indiana by Hay (*Carn. Inst. Wash. Publ. (322):1–499*, 1923). Platt (*Proc. Indiana Acad. Science (40):361–367*, 1930) surveyed the herpetofauna of Morgan County, which lies directly to the south of Johnson County, and Smith and Minton (*Amer. Midl. Nat. 58 (2):341–351*, 1957) recently published on the distribution of Indiana reptiles and amphibians.

Description of locality.—The Tipton till plain is a flat, glaciated area making up the northeastern two-thirds of the county (Fig. 1). It is covered by till of the Wisconsin glaciation and is highly modified by agriculture. The Shelbyville moraine is an area of rolling hills that covers much of the southwestern third of the county and represents the terminal moraine of the Wisconsin glacier. Its steeper hillsides and stream valleys are relatively free from cultivation. The Knobstone escarpment, the northern extension of a highly dissected, unglaciated plateau, is found in the southwest corner of Johnson County. Only its mature stream valleys are under cultivation.

There are three large streams in Johnson County. The west fork of White River cuts off about 10,000 acres in the northwest corner, Blue River cuts off about 14,000 acres in the southeast corner, and Sugar Creek courses along the border of the eastern two-thirds of the county.

The vegetation is transitional between beech-maple climax to the north and mixed mesophytic to the south. The Knobstone area is often referred to as the chestnut-oak upland as these trees are often dominant on the ridges of the Knobstone hills.

Annotated List.—The following list represents the results of 53 collecting trips made during the interval of September, 1952 through May, 1953, some trips were made every month. I wish to thank Dr. Sherman A. Minton for his advice during this study.

Eurycea longicauda longicauda Green.—Found only in the Knobstone escarpment. Abundant under litter and shale near stream beds. Seventy-five were collected in one hour at Indian Creek in the Knobstone escarpment. This species may occa-

sionally be seen moving in the open on overcast days. Not taken later than October 7 or earlier than April 9.

Eurycea bislineata rivicola Mittleman.—Abundant under litter and rocks near stream beds in the Shelbyville moraine and Knobstone escarpment. Heavy agriculture probably accounts for the absence of records of this species from the Tipton till plain for it occurs in certain areas north of Johnson County. Stomachs of eight individuals examined February 20, 1953, contained spiders and earthworms. This species was active every month of the study.

Plethodon cinereus cinereus Green.—The most abundant *Plethodon* in Johnson County. Found on hillsides and ridges under leaves, rocks, and logs in the Shelbyville moraine and Knobstone escarpment, but was not found in the Tipton till plain. This animal is also found to the north of Johnson County in less cultivated areas. *P. cinereus* was active every month of the study, and during the colder months more deeply penetrated the leaf litter and friable soil of the Knobstone hills. Stomachs of eight specimens found under several inches of litter in December and February contained earthworms, spiders, centipedes, and snails. In the Knobstone escarpment the striped (red-back) and unstriped (lead-back) phases are commonly taken under the same log; in the Shelbyville moraine, where the land is more intensely cultivated, populations of *P. cinereus* are restricted to uncultivated hillsides and stream valleys, and either one color phase or the other appears to be dominant. Only the striped phase was found in a hillside population at the Johnson County Conservation Club acreage near Nineveh in the Shelbyville moraine, while only the unstriped phase was found in a stream valley population at Sugar Creek near US Highway 31.

Plethodon dorsalis Cope.—Found only in the Knobstone escarpment. Both *P. dorsalis* and *P. cinereus* are found together under piles of litter and leaves. *P. dorsalis* was active throughout every month of the study.

Plethodon glutinosus glutinosus Cope.—Found in the Knobstone escarpment only. It frequents hillsides and ridges under logs and leaf litter. In contrast to the other species of *Plethodon* which occur in Johnson County it is not active in the winter months.

Bufo terrestris americanus Holbrook.—Only one specimen was found in Johnson County. This is a large female from Needham Township in the Tipton till plain, March 20, 1953.

Bufo woodhousei fowleri Hinckley.—Common throughout the county. Fowler's toad persists in urban and agricultural areas.

Hyla crucifer crucifer Wied.—Common in wet

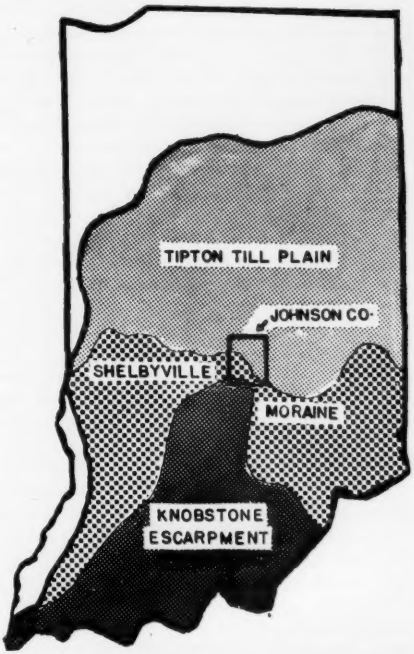

Fig. 1.—Physiographic provinces which contact Johnson County, Indiana.

situations throughout the county. First choruses heard March 20.

Pseudacris nigrita triseriata Wied.—Common in wet situations throughout the county. Date of first choruses same as *H. crucifer*.

Rana clamitans Latreille.—Common in permanent aquatic situations throughout the county.

Rana pipiens sphenocephala Hinckley.—Abundant in almost every aquatic situation in the county.

Chelydra serpentina serpentina Linnaeus.—One was taken from a pond near Blue River in the Shelbyville moraine and one from Indian Creek in the Knobstone escarpment.

Sternotherus odoratus Latreille.—Abundant in the sluggish parts of Sugar Creek and Blue River in the Tipton till plain and Shelbyville moraine as well as most permanent ponds throughout the county.

Chrysemys picta marginata Agassiz.—Common in sluggish parts of streams throughout the county. Abundant in permanent ponds. It shuns the swifter waters of Sugar Creek and Blue River. Active as late as November 8 and as early as March 12.

Graptemys geographica LeSueur.—Seen bask-

ing frequently at Sugar Creek and Blue River in the Tipton till plain and Shelbyville moraine.

Terrapene carolina carolina Linnaeus.—Rare in Johnson County. One DOR found near Samaria in the Knobstone escarpment. Forms made by these turtles were observed in the Knobstone escarpment four miles south of Trafalgar.

Trionyx ferox spinifera LeSueur.—Collected from Indian Creek in the Knobstone escarpment, seen basking in Blue River, in the Shelbyville moraine, and collected from Hurricane Creek in Franklin, Indiana. Franklin lies in a zone of transition between till plain and moraine.

Eumeces fasciatus Linnaeus.—Only one specimen was found. This record is from the Knobstone escarpment south of Samaria.

Sceloporus undulatus hyacinthinus Green.—Two large males taken at Indian Creek in the Knobstone escarpment, May, 1953, are the only records from the county.

Natrix sipedon subsp.—Common in permanent aquatic situations throughout the county. Most are intergrades between *N. s. sipedon* and *N. s. pleuralis*.

Natrix kirtlandi Kennicott.—One was collected at a vacant lot in Franklin, Indiana in the transition zone.

Thamnophis sirtalis sirtalis Linnaeus.—Common throughout the county near aquatic situations.

Heterodon platyrhinos platyrhinos Latreille.—Single specimens were collected at Budd, Nineveh, and near Blue River in the Shelbyville moraine area.

Diadophis punctatus edwardsi Merrem.—One specimen was found in the Knobstone escarpment four miles south of Trafalgar.

Coluber constrictor sub sp.—Found throughout the county. Most are intergrades between *C. c. priapus* and *C. c. flaviventris*. A DOR from near Nineveh in the Shelbyville moraine was very close to *priapus*.

Elaphe obsoleta obsoleta Say.—Two were collected near Nineveh in the Shelbyville moraine, and one from Hurricane Creek in the Tipton till plain.

Ancistrodon contortrix makeson Daudin.—One large female was collected from the Knobstone escarpment four miles south of Trafalgar. Minton (personal communication) has collected other copperheads at this locality.

Discussion.—The northern range of *Plethodon glutinosus, Eurycea longicauda, Sceloporus undulatus,* and *Ancistrodon contortrix* appears to be limited to areas south of the Wisconsin glacial boundary in Indiana and Illinois (Smith and Minton, *Amer. Midl. Nat. 58 (2):1–199, 1957*). This holds true in Johnson County where the above forms are limited to the unglaciated Knobstone escarpment.

Smith and Minton (*ibid.*) have categorized certain amphibians and reptiles in Indiana and Illinois as indicator species for four faunal elements. Johnson County has representatives of all four: Northern, bog relict, cold tolerant, damp grassland indicator, *Natrix kirtlandi*. Southern, forest or forest edge indicators, reaching the northern limit of their distribution in southcentral Indiana, *Plethodon glutinosus, Eurycea longicauda, Sceloporus undulatus,* and *Ancistrodon contortrix*. Eastern indicators distributed over the originally forested portions of Indiana, *Plethodon cinereus, Eurycea bislineata, Rana clamitans, Eumeces fasciatus, Diadophis punctatus,* and *Elaphe obsoleta*. Western, prarie relict indicator, *Bufo woodhousei*. Thus the indicators in the Johnson County herpetofauna include six eastern and four southern forms, with one northern and one western relict.—J. Alan Holman, *Department of Biology, University of Florida, Gainesville, Florida.*

AUTUMNAL BREEDING OF *HYLA CRUCIFER*.—The reproductive activity of most species of frogs is closely associated with seasonal changes in light and temperature and with precipitation. For some species, such as spadefoot toads, lowering of the barometric pressure provides a primary impetus for reproductive behavior. How these physical factors interact with each other and with the intrinsic metabolic processes of various species is not fully understood. The following observations pertain to this problem.

Hyla crucifer generally breeds in the early part of the season when both air and water temperatures are relatively low. In the southeastern states the first calls usually occur in late December or early January, the peak of the egg laying season in late February or early March, and the last calls of the season in early May. An interesting exception to this seasonal pattern occurred in northeastern Georgia on September 27, 1958. Numerous scattered calls were then heard in the area between Clayton, Rabun County and Athens, Clarke County. Moreover, a mass of eggs was found at Athens in a small pool of a woodland stream that was about a foot wide and two inches deep. The eggs were taken into the laboratory where they hatched into apparently normal tadpoles that were reared for two weeks and then preserved.

In the Athens area, September is usually hot and often has dry spells of more or less serious magnitude. In 1958 the rainfall was only 1.22 inches, well below the average for the month (3.61 inches). The calling and spawning on the 27th were associated with the passage of a weak

cold front accompanied by widely scattered showers. Near Athens, only a trace of precipitation fell; however, the average daily temperature was lowered from 78 degrees F. on the 27th to 64 degrees on the 28th. A relatively small change in barometric pressure accompanied the frontal passage. Prior to noon the barometric pressure on the 25th was steady at about 29.30 inches; it then decreased slowly to 28.88 inches on the afternoon of the 27th; a slight increase occurred after the frontal passage. Obviously, the most impressive weather change on the 27th was the 14 degree drop in temperature.

It is particularly noteworthy that no other species of frogs called on the 27th. Conspicuous among those not calling was *Pseudacris triseriata*. This species occupies the same general foraging and breeding habitats as does *crucifer*; however, it usually begins and completes its reproductive activity about two weeks prior to *crucifer*. The absence of *triseriata* was probably due to its somewhat lower thermal requirements for reproduction. Probably *triseriata* would have called had the temperature been lower. Another factor that may have contributed to the absence of still other early breeding species, especially *Rana pipiens* and *Bufo americanus*, was the absence of suitable breeding habitat—puddles and small ponds. On the other hand, later breeding species were absent possibly because they did not have ample time for the development of gametes. Thus a second breeding during the same year is virtually impossible for such species.—BERNARD S. MARTOF, *Department of Zoology, University of Georgia, Athens, Georgia.*

NOTES ON FEEDING BEHAVIOR OF AN AFRICAN EGG-EATING SNAKE.—The African snakes of the genus *Dasypeltis* have long attracted interest because of their adaptations for eating birds' eggs, which appear to be the sole food. Egg eating snakes of other genera (with the possible exception of *Elachistodon*) are not very modified for such food, nor are they restricted to it. As a corollary, only the larger individuals of such species as *Elaphe obsoleta* are able to cope with eggs like those of the domestic chicken. Few *Dasypeltis* exceed one meter in length, and Gans (*Ann. Mus. Roy. Congo Belge, 74:167*, 1959) has stated that "... without the dasypeltine mechanism even moderate to large sized individuals of most species of the genus would barely be capable of ingesting the smallest available eggs." The functional morphology involved has been greatly clarified by earlier work of Gans, but much remains to be learned of the behavior of these snakes under natural and laboratory conditions. In particular, some observations made at the Chicago Zoological Park suggest that there are distinctive actions preliminary to eating relatively large eggs that deserve further study, especially with small specimens, in which such behavior would likely have great survival value.

Our specimen, a "*lineolata*" phase female of *D. scabra* shipped from Nairobi, Kenya, was about 85 cm. in total length and weighed 180 g. before feeding in the spring of 1957. For the previous three years she had been receiving pigeon, parakeet, pullet, or robin eggs, when available, at monthly intervals and had shown no noteworthy reactions. Then for three feedings we offered her the largest chicken eggs available, all about the same size and weight (average: 54.7 × 41.4 mm. and 51.2 g.).

In each of these three instances she approached the egg and touched it with short strokes of her tongue. She then began to "measure" the egg with the head and anterior part of her body by closely curling over and around it several times with no tongue action or attempts to ingest it (Fig. 1a). Following this she moved away from the egg and began limbering up exercises like an athlete before a contest: the mouth was widely opened and while one mandible remained in a ventral position, the other swung dorsomedially away from its lower labials, stretching the gums considerably (Fig. 1b). This action, which alternated from side to side, involved extensive lateral movements of

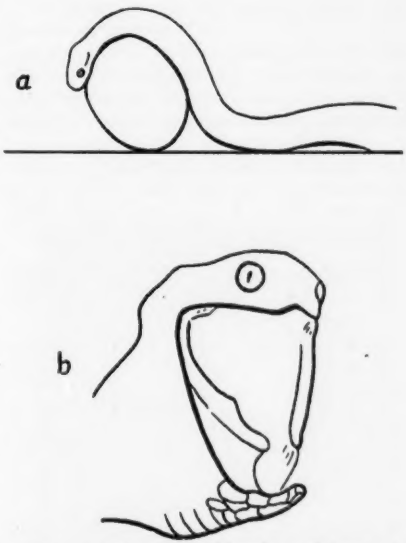

Fig. 1.—Behavior of *Dasypeltis scabra* preliminary to ingesting a relatively large egg. *a*, curling over or "measuring" an egg; *b*, stretching, the left mandible in ventralmost position and the right mandible about halfway in its swing. Drawn from 16 mm. motion picture film.

the supratemporal and quadrate bones and also stretched the neck skin to approximately the degree shown when a large egg is partly engulfed. The ventral scutes and chin shields member of the engulfing mechanism (Gans, *Zoologica, N. Y., 37 (4):233*, 1952) appeared to be exercised as a unit and also, perhaps, in sections. The curling of the chin tip at the extreme of each mandibular movement (slight in fig. 1b) may have been due to pull by the short muscle attached to the raphe of the first labials (*ibid.: fig. 9*). After these maneuvers the snake approached the egg and began swallowing it in the fashion described by Gans. Initial cracking occurred after 15 to 20 minutes and ejection 45 to 70 minutes later. When the egg was collapsed the snake became restless and eventually moved to the edge of the feeding platform and ejected the shell over the edge.

After these three feedings this specimen quickly abandoned preliminaries of any sort, even with the largest chicken eggs—recognition presumably being entirely visual. She has become quite used to being fed from one's hand and in strange situations. Shell ejection over edges, which may be a non-alarming nest robbing habit, has been retained. Now in her sixth year of captivity, she had reached a total length of 950 mm. and weighed 227 g. before feeding in late August, 1959.

Our interpretation of the stretching behavior seems supported by observations made by Neil D. Richmond of Carnegie Museum. He has twice seen similar movements by a specimen of *D. scabra* when he offered it an egg of accustomed size a few hours before it shed. Such an egg may be *relatively* large owing to lessened suppleness of the skin or some other pre-shedding factor. Richmond's specimen also practiced shell ejection over edges when given the opportunity.

We wish to thank Neil Richmond for the use of his notes and Carl Gans for scrutiny of the typescript.—George B. Rabb and Robert Snedigar, *Chicago Zoological Park, Brookfield, Illinois.*

GREEN ANOLE THREATENS WASP.—On March 25, 1959, I made the following observation of the behavior of a Green Anole, *Anolis carolinensis*, and a wasp, *Polistes rubiginosus*, at Lake Alice on the campus of the University of Florida, Gainesville.

I was standing about ten feet from a pile of boards lying on the shore of Lake Alice when an anole scurried from inside the pile and stopped on the end of the topmost board; the anole was completely dark brown. The anole remained still for about one minute, then it began to turn a pale green. A wasp flew toward the anole and hovered about two feet from its head. At once the anole turned a brilliant green, flattened its body laterally, slightly erected its dewlap, and turned it body so as to present its side to the hovering wasp.

Then the wasp flew to within about six inches of the anole's head, and the lizard's response was immediate: it compressed its body even more, fully erected its dewlap, and then began to bob rapidly up and down. The dewlap turned a bright pinkish-red. The head, front legs, and forepart of the body were involved in the anole's bobbing movements. The wasp retreated about a foot, then flew to a position in front of the anole which immediately oriented its body so as once more to present its side to the wasp. The wasp backed off and hovered about a foot away; the lizard stopped bobbing and started to lower its dewlap, which began to fade to a dull pink.

The wasp made a total of six "passes" at the head of the anole, and the above sequence was repeated each time by the lizard. Full erection and red color change of the dewlap, together with bobbing, occurred only when the wasp flew close to the head of the anole. At each pass, the wasp "attacked" from a different quarter, but the anole quickly moved so as to orient its body laterally toward the wasp. The wasp finally flew away, and the anole relaxed, fully lowering its dewlap and slowly resuming the dark brown coloration. Throughout the encounter, the entire body of the anole was a brilliant green, except for the color of the dewlap. The entire sequence took about two minutes; the anole remained motionless for an additional minute or two, then it scurried away.

This species of wasp can deliver a painful sting to a man and conceivably it could disable a small lizard. It is interesting that the green anole may give the same responses (color change, dewlap erection, and bobbing) to a potential enemy of another species that it commonly shows in intraspecific social behavior.—Andrew J. Meyerriecks, *Hatheway School of Conservation, South Lincoln, Massachusetts.*

OVULATION TIME IN THE MUSK TURTLE, *STERNOTHAERUS ODORATUS*.—On April 30, 1955, a series of 8 female musk turtles was captured in Rockland Lake, near Burlington, Racine County, Wisconsin. For details of capture and handling see Edgren and Edgren (*Herpetologica, 11:213–217, 1955*). On May 3, 1955, these turtles were sacrificed and autopsied primarily for study of seasonal changes in bone (Edgren, in preparation). Incidental to the primary observations the gonads were weighed and the turtles were examined for the presence of ovarian and/or oviducal eggs.

Four of the turtles had oviducal eggs, whereas

TABLE I

AUTOPSY DATA ON 8 *Sternothaerus odoratus*, CAPTURED ON APRIL 30 AND SACRIFICED MAY 3

Turtle Number	Carapace Length* (mm.)	Body Weight (g.)	Ovarian Weight (g.)	Ovarian Eggs**	Oviducal Eggs
1	94	139	9.5	10	0
2	84	101	6.1	4	0
3	87	112	8.4	7	0
4	97	134	8.1	6	0
Mean	*90.5*	*121*	*8.0*	*6.8*	
5	92	107	3.5	0	3
6	93	134	4.2	0	3
7	88	122	5.0	0	4
8	92	132	5.3	5	4
Mean	*91.2*	*124*	*4.5*		*3.5*

* Straight line measurement.
** Refers only to large eggs.

the remaining four contained large ovarian eggs that seemed ripe and ready to ovulate (Table 1). Turtle number 8 contained both oviducal eggs and large ovarian eggs. These data suggest that ovulation in this species occurs in late April or early May at this latitude; turtle number 8 probably had only partially ovulated by May 3. In only one of the turtles was there any evidence of calcification of the shell of the oviducal eggs. Expulsion of the egg from the ovary appears to result in a considerable decrease in weight of the ovary itself, which is not surprising in view of the fact that 10 viable eggs removed from 3 females on June 9, 1955, averaged 4.02 ± 0.08 grams.

The actual date of egg laying in southern Wisconsin is unknown, although natural nests were discovered on June 29 (Edgren, *Chicago Acad. Sci., Nat. Hist. Misc., 53:1, 1949*). In addition, since viable eggs were removed from turtles on June 9 (Edgren, *Chicago Acad. Sci., Nat. Hist. Misc., 152:1, 1956*), natural oviposition probably takes place in middle or late June. Thus the life of the egg in the oviduct of this species must be between 5 and 8 weeks.—RICHARD A. EDGREN, *Division of Biological Research, G. D. Searle and Co., Chicago, Illinois.*

FIGHTING AND AN INCIPIENT NOTION OF TERRITORY IN MALE TREE FROGS.—The notion of territory and the habit of fighting between males are not generally associated with frogs but rather with birds and mammals. Nevertheless, there are rudiments of their occurrence among neotropical frogs. *Hyla faber* (Fig. 1), one of the largest tree frogs in Brazil, has acquired the interesting habit of building nest-pans for spawning. This habit is tied to a pattern of nuptial behavior that is more complex than the usual reproductive behavior of frogs. It involves a rudimentary sense of territory and fighting among the males.

A good opportunity for observing and photographing *Hyla faber* and its activities was afforded the author, her brother, Professor Gualter A. Lutz, who took the photographs, and our assistant, the late Joaquim Venancio, during the summer of 1951, at the "Açude da Solidão" in a clearing at the edge of the montane Tijuca forest, outside Rio, at approximately 380 m. of altitude. The observations were continued by the author in 1959.

This irregularly elongate pool is formed by a brook coming down from the mountains. Formerly it was a small marsh but the pool was deepened, a dam was built at the lower end, and an open path planted with trees provided around it. Ornamental vegetation was later brought in from outside. The place is protected against depredation, as it is on government land and has a resident guard. A colony of *Hyla faber* has become established beside this pool; this is apt to occur when a quiet artificial pond is provided in a place, such as the edge of montane forest, poorly endowed by nature with the right biotope for the larvae. Similar colonies have been observed elsewhere, for instance in the Biological Station of Paranápiacába, at Alto da Serra, near the city of São Paolo, at 800 m. of altitude.

The nests are rounded pans, mostly with raised clay walls, built inside pools of standing water, either at the edges or in shallows (Fig. 3). They have been known for a long time (Goeldi, *Proc. Zool. Soc. London, 1895*:89–97), but the details concerning their building were not all discovered nor quite accurately presented. Contrary to Goeldi's statement, it is the male, not the female, who does the building.

The male builds the nest by getting into the water, sitting in a shallow place and circling

Fig. 1.—*Hyla faber* Wied.

Fig. 2.—A male *Hyla faber* starting to build the nest. Note the spread of the hands.

When the nest is finished, and sometimes even before, the male starts singing, sitting either on the rampart, inside the cavity, or even outside it, but in the vicinity. Females ready to spawn seem to be attracted by the drumming of the males. They approach, halting now and then in a peculiar position, sitting with the fore part of the body elevated. After a time they get into the nest and eventually swim up to the male from behind and lay a hand on his back. At first he just goes on calling, then suddenly he turns and seizes the female.

Fights between male *Hyla faber* were witnessed several times. They may break out in the nest or outside it. The fighting males encircle each other's heads and necks with the arms and place their hands into positions that permit them to drive the sharp, curved pollex rudiments into the

Fig. 3.—Nests of *Hyla faber* in different stages of construction at the edge of a pool.

around, thus forming a rounded cavity and gradually deepening it. He forms the walls by pushing up the clay and patting it onto the edges of the nest with hands (Fig. 2). Occasionally, the frog goes under, brings material up on the snout, and pushes it onto the wall with the hands. It is difficult to see into the muddy hole, but the feet are probably used in the same manner as the hands. The finished and perfect nests are rounded and from 27 to 33 cm. in diameter, and from 7.5 to 9 cm. deep. The rampart may rise some 5 to 7 cm. above the water.

enemy. Meanwhile, they may wrestle with the long legs and try to push each other under while keeping their own nostrils above water. Sometimes they thrash around; at other times they lie quite still with the legs drawn up under the body, which is as much inflated as possible. If one is stronger, or more agile, he gets on top and seems to try to drown the other.

When the fight begins inside the nest the frogs may fall out and continue to fight, either on shore (Fig. 4), or in the pond; sometimes they break off and move away. A pair of fighters can

Fig. 4.—Two male *Hyla faber* fighting on shore. The peculiar position of the hands permits driving in the pollex rudiments. All photographs by Prof. Gualter A. Lutz.

be lifted up together and moved so as to be examined. It is then seen that the skin round the rudimentary pollex is pushed down and the sharp curved point is bare. The fighters may have both their pollices dug into the foe. If one gently lifts a pollex out, it is promptly pushed in again. It is only after some handling that they seem to realize the change, break apart, and hop away. One of a pair of fighters, thus lifted out, proved to be a male that had been singing, the night before, inside the nearest nest. He was easily recognized by his individual pattern.

The seriousness of the wounds depends on the point reached. On one occasion a dead male *Hyla faber* was pulled out of the pond and showed a trickle of blood just beside the tympanum. In prolonged amplexus the female may also be severely wounded by the pollices and perish in consequence.

Amplexus is very persistent, the male holding the female forcibly. During mating inside the nest, he repeatedly presses her down so hard that she is pushed under. While trying to come up she sometimes brings sand or clay from below and spreads it with her hands along the inside of the rim. This is the only contribution of the female towards building that we have observed. It may also be the origin of Goeldi's statement, in his second observation, "that the male frog is present during the erection of the nest or pool, in a perfectly passive manner, however, that is sitting on the back of the female."

Breder (*Bull. Amer. Mus. Nat. Hist., 86:375–436, 1946*) observed the nests of *Hyla rosenbergi* Blgr. in Panama, but does not mention fighting between the male frogs.—Bertha Lutz, *Naturalist, Museu Nacional, Rio de Janeiro, Brazil.*

Ichthyological Notes

FOUR SHARK ATTACKS ON THE WEST COAST OF FLORIDA, SUMMER 1958.—During the summer of 1958, four cases of shark attack occurred within a period of five weeks along the sixty-mile stretch of beach between Sarasota and Sanibel Island on the lower West Coast of Florida. The water temperature in these four cases was approximately 30° C. The case of

Douglas Lawton, resulting in the amputation of his leg, was the most serious shark attack recorded from the West Coast of Florida in 38 years (Hutton, Fla. State Bd. Conser. Educational Ser. 13, 1959). Details of the Lawton attack are reported here, along with brief accounts of the three other cases, in the order in which they occurred. The sharks involved were probably Nurse Sharks, *Ginglymostoma cirratum* (Bonnaterre), a Tiger Shark, *Galeocerdo cuvier* (LeSueur), and an unidentified shark.

(1) CASE OF FRANK A. MAHALA, AGE 17

The attack was on June 24 about 5:10 p.m. The attack took place about ten feet from shore in the surf at Turtle Beach, Siesta Key, about one mile south of Point of Rocks, Sarasato. The water was about 2½ feet deep, murky, and the bottom was composed of sand and shell. Mahala was walking toward shore when the shark attacked from behind. Mahala wore plain bathing trunks, no shiny objects. He felt only one bite, which severed the nerves of the lower part of his left leg and foot. From the wounds it is obvious that several other bites were made which he did not feel. No one else was in the water but several persons had just left to prepare food on shore.

The boy's uncle and cousin pulled him from the water and he was driven to a hospital. He was treated by Dr. James O. Fergeson of Sarasota, who reports that there were "severe lacerating wounds of the left leg and foot with complete severance of the tendons of the tibialis posterior, flexor hallucis longus, flexor digitorum longus, partial severance of Achilles tendon, complete severance of the posterior tibial artery and partial severance of the posterior tibial nerve. A wound on the dorsum of the foot below the major injury consisted of multiple puncturing wounds in a line apparently caused by the fish's teeth. Corresponding to this wound on the dorsum of the foot was a wound on the plantar aspect which was irregular and jagged, being shaped like the teeth of a heavy saw". Dr. Fergeson also reported that he felt, from the character of the wounds, that the fish was large enough to take the boy's entire foot in its mouth, but was not strong enough to bite through the tibia. The boy recovered and was able to walk satisfactorily. After Dr. Fergeson treated the fourth victim on this list he concluded that Mahala was definitely attacked by a shark with sizable teeth—not a Nurse Shark. I obtained the information on this attack personally from Dr. Fergeson and from correspondence with Frank Mahala.

(2) CASE OF ERIC N. COCKERILL, AGE 59

The attack was on June 26 about 5:30 p.m. The attack took place off Sanibel Island, about 30 feet from shore on a shallow sand bar where the water was about three feet deep. No one else was in the water. Cockerill, wearing yellow bathing trunks, was wading and has the impression that he walked into the shark's mouth with his right foot. The shark evidently was resting on the bottom. Cockerill raised his right foot from the water and saw the shark's head clamped onto his foot. The shark then let go and swam away. The victim made his way painfully a considerable distance to his home. A visiting doctor controlled the hemorrhage and gave the victim medicine to relieve the pain. He was then taken to Lee Memorial Hospital, Fort Myers, where Dr. Baker Whisnant attended him. The wounds were sutured and subsequently healed satisfactorily. Several months later numbness and pain developed in the foot and Cockerill is being treated by an orthopedic surgeon.

Cockerill's scars indicate clearly that the shark had the foot in its mouth. On the bottom there was a curved cut; the top of the foot, in line with the bottom cut, was torn or shredded as if by many small teeth set close together. The victim described the fish, which he did not know was a shark, as being brown in color, having a large head with a blunt snout, an oval mouth and thick brown lips. From the scars on his foot it is estimated that the width of the mouth was approximately 140 mm. The shark was undoubtedly a Nurse Shark of at least seven feet. Information on this case was secured through Mrs. Gay Thomas, an X-ray technician who interviewed the victim, and Dr. Robert Greenwood, an orthopedic surgeon now treating the victim.

(3) CASE OF JON HAMLIN, AGE 22

The "attack" was on July 2 about 2:30 p.m. This case and perhaps the preceding one should be listed as "provoked" attacks. This incident took place about ten feet from shore at the south end of Point of Rocks, Siesta Key, Sarasota. The water was six feet deep and fairly clear. Hamlin was skin diving and saw a Nurse Shark about 5½ feet long lying among the rocks. He grabbed the shark by the tail with both hands and tried to pull it to shore while swimming backwards. The shark swerved from side to side and finally grabbed the inner part of Hamlin's left leg about two inches below the knee. Hamlin let go of the shark and it then released its grip and swam away. The victim rested on the beach for about half an hour, at which time bleeding from the wound had practically stopped

and he felt well enough to continue skin diving. The wound left a curved scar almost two inches across and shows the fine markings of the individual small teeth. I obtained this information from Hamlin, a personal friend.

(4) CASE OF DOUGLAS LAWTON, AGE 8½ YEARS

The attack was on July 27 about 4:10 p.m.

Place of attack.—The attack took place in the Gulf of Mexico less than ten feet from shore at Longboat Key, Sarasota. The water was about three feet deep and murky.

Description of attack.—The victim and his brother, age 12, were swimming in the water. Both wore green face masks, green foot flippers, and red and green bathing trunks. Their parents, aunt and uncle were sitting on the beach watching them; no other people were in the water. No one saw the shark approach the victim. The first sign of the attack was when the boy screamed and was pulled off his feet, going almost completely under water. The water immediately turned red. The victim's brother grabbed him and held his head up. The shark was then seen for the first time, striking at the victim's leg. The four adults rushed into the water and started pulling the victim out. The dorsal side of the shark's head was then clearly seen by all as it still hung onto the inner surface of the victim's left thigh, its head pointing to the left side of the vicim. The latter tried to dislodge the shark's head with his left hand. His uncle held the boy by his shoulders and the boy's father grabbed the tail of the shark and pulled it until it released its grip. The shark then floundered from the very shallow water next to shore into deeper water and disappeared.

Treatment and nature of wound.—A tourniquet was applied high on the thigh and the boy was rushed to Sarasota Memorial Hospital where Dr. James Fergeson attended him. It was necessary to amputate the entire leg as the wound high on the thigh had much of the muscles and the major blood vessels torn away to the bone.

There were three major wounds, apparently from three separate tearing bites: the most severe wound on the thigh, just noted; a large wound 75 mm. wide across the middle of the calf; and a wound 26 mm. wide across the dorsum of the foot (see Figures 1 & 2). All three of these wounds had jagged edges and along much of these edges the marks left by the points of the shark's teeth could be distinguished; in addition, there were numerous superficial scratches and bites showing marks left by individual teeth (Figures 2 & 3). There was no evidence of the shark attacking any other part of the victim except on the left leg. The victim's left hand, however, was scratched and cut by the shark's teeth when he tried to dislodge the shark from his leg.

The victim's brother had three short scratches on one of his legs. They were 25 mm. apart, the same distance of the deep scratches on the victim's leg and apparently were made by the shark's teeth brushing against the older brother's leg when he was holding the victim.

Description of shark.—The four adults and two boys all agree on the following: The shark was about five feet long or a little longer, blue-gray in color, slim and streamlined in general appearance but with a very blunt snout. The bluntness of the snout was stressed by these observers who thought it unshark-like because they thought a shark's head was pointed. None of

Fig. 1.—Outer side view of left amputated leg of shark victim, age 8½ years.

Fig. 2.—Inner side view of same.

Fig. 3.—Enlargement of teeth marks of shark attacker just below the knee of the amputated limb.

them could recall noticing any markings on the shark's body, but they reported to have gotten a good look only at the head and did not pay much attention to the body as they were concerned only with the victim at the time.

It is the writer's opinion that the teeth marks on the victim's leg could have been made only by a Tiger Shark. Most of the marks left by individual teeth show that the shape of the tooth was strongly asymmetrical. The tip of each tooth pointed obliquely to one side and had a deep notch on this same side. Teeth marks identical to those on the boy's leg could be duplicated by the teeth of preserved jaws of Tiger Sharks in a block of clay. Our laboratory has a large collection of shark's jaws and the front teeth marks (it is considered unlikely that the superficial wounds on the victim's leg could have been made by side teeth) of other blunt headed local species could not be made to resemble the teeth marks of a Tiger Shark though made at various angles. The width between the scratch marks on both boys' legs (25 mm.) approximately matches the width between the alternate front teeth of a Tiger Shark between five and six feet long. The alternate teeth of the Tiger Shark are brought into aligning rows as they grow outward. The general description of the shark by the eye-witnesses also fits that of a young Tiger Shark. The markings of a Tiger Shark, mostly on the sides of the body, could easily have been missed by the witnesses. When a photograph of a dorsal view of a seven foot Tiger Shark was shown to the victim's brother, father, aunt and uncle, they all agreed that it strongly resembled the shark which attacked the boy.

Special Notes.—The locality where the attack took place was studied in an effort to find possible clues for the cause of the attack. There is a long sand bar about 25 yards from shore running almost the entire length of Longboat Key, a distance of nearly eight miles. Four days after the attack the writer took a boat along both sides of this sand bar. It was estimated that the depth of water over the sand bar at the time of the attack must have been only a few inches (low tide on July 27 was at 5:57 p.m.). The channel inside the sand bar is about five feet at its deepest point, the channel leads into deeper water (about ten feet) in Longboat Pass at the north end of the Key and leads into New Pass (about 15 feet depth) on the south end of the Key. The water next to the beach drops sharply from a few inches to three feet. It is possible that the shark swam over the sand bar earlier in the day and then found itself trapped in the channel as the tide became lower; or it may have swam into the

channel from either of the passes at the ends of Longboat Key. The victim and his brother were the only people in the water at the time and the shark swimming within the confines of this channel might easily have detected the vibrations made by the boys slapping their foot flippers at the surface of the water. The victim's feet and ankles were not as deeply tanned as the rest of his legs as he usually wore shoes and socks on his feet when playing in the sun. It seems possible that the shark, attracted by the vibrations made with the flippers, saw the pale lower portion of the boy's leg and struck at that point, first causing the large wound on the foot (the victim's left flipper was lost, presumably during the attack). The shark which attacked Frank Mahala on June 24, nine miles south, could conceivably have been the same species and possibly the same individual shark. The latter is considered doubtful, but in view of Coppelson's (*Shark Attack*, 1959) evidence supporting his theory of "rogue sharks"—individuals of which become "man eaters" after a successful first attack—this could be the explanation for the unusual occurrence of these two unprovoked attacks so close together in time and location in an area where no similar attack has been reported in 38 years.

The writer personally interviewed the victim, his brother, mother, father, aunt and uncle. I examined and studied the amputated leg in the pathology laboratory of Drs. Millard B. White and John S. Bracken in Sarasota. Photographs were originally taken in Kodachrome by Dr. White. Photographic copies in black and white were made by the photography department of the American Museum of Natural History.

Photographs, documents, newspaper clippings and more detailed reports of these four cases have been submitted to the Division of Fishes at the Smithsonian Institution for their file on shark attacks. The writer is deeply grateful for the cooperation of the many people mentioned above in preparing this report.—EUGENIE CLARK, *Cape Haze Marine Laboratory, Placida, Florida.*

RESTRICTION OF THE CROAKERS (SCIAENIDAE) AND ANCHOVIES (ENGRAULIDAE) TO CONTINENTAL WATERS.—The sciaenids are marine fishes of primarily tropical distribution, with relatively few members adapted to cooler temperate waters. Some croakers enter fresh water and there are a number of freshwater tropical species (*Plagioscion*, etc.), in addition to *Aplodinotus* in the Mississippi system. I have called such forms vicarious freshwater fishes (Myers, 1949, *Bijdr. Dierk., 28: 315–22*).

One of the interesting facts to be noted about the entering of fresh water by different families of marine fishes is that the areas where such euryhaline tendencies are most evident seem to depend on the climatic zone to which the family is primarily restricted. Gray-mullets (Mugilidae), for example, are primarily tropical in range, and they enter fresh water more extensively in the warmest parts of the family range than they do in cooler localities; only in the tropics are there really freshwater mugilid species such as *Mugil xinguensis* Steindachner, *Rhinomugil corsula* (Hamilton), and *Agonostomus*. On the other hand, in some cold-water families of euryhaline tendencies (salmonids, including whitefishes, for example), moving from salt to fresh water, or the reverse, seems to be commoner in the coldest parts of the family range. Although I have had no personal experience in the far north or far south, I can add my impression to those recorded by Gunter (1957, *Copeia: 13*) that, in the tropics, the young of marine fishes more often show up in brackish or fresh water than the adults. This is especially true of *Lutjanus*.

However, a good many of the species of tropical croakers never enter fresh or brackish water. Species living on coasts such as that of Perú have no estuaries to enter, for the coastal strip is a virtually rainless desert almost devoid of streams. Moreover, certain sciaenids living on tropical coasts replete with rivers probably never enter brackish water.

Despite these facts, an important but unnoticed feature of the geographical distribution of the Sciaenidae is the strict confinement of the family to *continental* coasts. Croakers are abundant and important fishes in the coastal seas of southeastern Asia, China, and southern Japan. They become somewhat fewer in species about the great continental islands of the East Indies (Borneo, Java, New Guinea) and in Australia. But as soon as these last continental outposts are left, the croakers disappear. They are completely absent among the fishes of the immense coral-island world of Oceania. In fact, their distribution in the Eastern Hemisphere seems to be confined to the shores of continents and of "continental islands", using that term in the geological sense as well as the zoogeographical sense of A. R. Wallace.

In the Western Hemisphere, much the same sort of distribution is seen, with one important exception. In tropical American seas, several smaller sciaenids have become adapted to live in coral reefs about small islands. Chief of these are the species of the genera *Equetus* and *Pareques*. Only these two genera appear to occur at Bermuda, and they are probably the principal sciaenids of the Bahamas and Lesser Antilles.

Yet the number of species of croakers about even such large islands as Cuba and Hispaniola is considerably smaller than along comparable stretches of the continental coast. Only two sciaenids seem to have reached the Galápagos, one endemic and the other a mainland species.

A much more careful study of sciaenid distribution would be necessary before it would be worth while to discuss the possible reasons for it. However, in some ways it resembles the distribution of the plankton-feeding anchovies (Engraulidae), which, although abundant on southeast Asian continental coasts, are almost absent in Oceania. Moreover, in America, anchovies shun most of the oceanic islands that are poor in croakers, and swarm along coasts frequented by sciaenids. Similarities to the distribution of several other familial or infrafamilial groups of marine fishes are also evident.

Certainly it cannot be said that croakers and anchovies flourish on elements in the marine environment supplied only on coasts with many rivers; nor in areas where nutrients are derived from upwelling. Yet there must be some reason for their peculiar distribution.—GEORGE S. MYERS, *Natural History Museum, Stanford University, Stanford, California.*

A FURTHER NOTE ON THE NIGHT SHARK, *HYPOPRION SIGNATUS*.—Following Bigelow and Schroeder *Mem. Sears Found. Mar. Res. 1(1):316–19, 1948*) there have been several bits of information added to our knowledge of the night shark, *Hypoprion signatus* Poey, 1868. Poll (*Res. Sci. exped. oceanogr. Belg. eaux cot. Afr. Atlant. Sud. 4(1):1–154, 1948–49*), Springer and Thompson (*Copeia 1957(2):160*), Mather and Gibbs (*Copeia 1957(3):242*) and Krumholz (*Copeia 1957(4):300*) have extended the recorded range for the species to the South Atlantic coast of Africa, Gulf of Mexico, waters east of Delaware Bay and Bimini, Bahama respectively. Most of these workers have reported this species being taken from depths exceeding 100 fathoms during both daylight and night hours. Springer and Thompson (*op. cit.*) and Krumholz (*op. cit.*) contribute further data on morphometric characteristics. The former authors indicate a greater variability than had heretofore been recorded.

Two females were taken by otter trawl during daylight hours by the Fish and Wildlife M/V *Delaware* off the South Carolina coast. The first specimen was taken on 24 February, 1959 from 118 fathoms on a course between Lat. 32° 10′ N. Long. 78° 58′ W and Lat. 32° 7′ 30″ N. Long. 79° 01′ 30″ W. This animal was 6 feet and one-quarter inch long. The gonads were small and undeveloped. It is inferred the animal was sexually immature. The second specimen was taken on 27 February, 1959 from a depth of 100 fathoms on a course between Lat. 32° 50′ N, Long. 77° 55′ 30″ W and Lat. 32° 53′ 30″ N, Long. 77° 55′ 30″ W. This specimen measured 7.5 feet in length and was carrying pups. There were six embryos in the right uterus, four of which were female. These six ranged in size from 16–17.25 inches with a mean of 16.8 inches. The left uterus contained eight young only two of which were females. The size range for the eight was 17–17.75 inches with a mean of 17.4 inches. The embryos were attached to large, very spongy placentae by means of long slender yolk stalks.

There were two undeveloped eggs in the right uterus encased in separate thin-walled, elongated cases resembling those of *Mustelus canis*. These eggs were elliptical in shape and approximately one inch in length. The right ovary was developed and contained many small spherical eggs one-quarter to three-eighth inch in diameter. The left ovary was small and contained no visible eggs.

An estimate can be made regarding size at the attainment of sexual maturity. Springer and Thompson (*op. cit.*) record several females 7.5 to 7.8 feet in length as being adult, and some of them carrying young. The data from the two females taken aboard the M/V *Delaware* indicate attainment of sexual maturity occurring between 6 and 7.5 feet in length. The males have been recorded as adult (mature) at 6.5 feet.

Thanks are due to James L. Squire, Jr. of the Fish and Wildlife Service, for providing facilities aboard the M/V *Delaware*. These observations were made possible by a National Science Foundation Research Grant, NSF-G4393. Marine Laboratories Contribution No. 12.—FRANKLIN C. DAIBER, *University of Delaware, Newark, Delaware.*

REDUCED SURVIVAL OF YOUNG ETHEOSTOMATINE FISHES AND HYLID TADPOLES DUE TO AMMONIA FUMES PRODUCED BY A RODENT COLONY.—During the past decade many experiments have been carried out at The University of Texas to determine the relative survival of hybrid anurans and fishes (Blair, *Southwestern Nat. 3: 77–89*, 1959; Hubbs, *Texas Jour. Sci. 11:49–56*, 1959; and others). These animals have been reared under a variety of experimental techniques to ascertain optimal rearing conditions. Temperature has been one of the variables considered to be most pertinent. Due to the warm climate of the Austin area, cooling below outside temperature appeared to hold promise. Until recently only the room cooled for the rodent colony was available for these experiments. The latter showed low sur-

vival with low temperature, a curious anomaly because the low temperature often approximated that of the natural environment during the reproductive period. Subsequent experiments on rearing similar animals at cold temperatures elsewhere were very successful. Thus, the above mentioned work casts doubt on the validity of the earlier published results listed at the end of this note.

During the winter of 1958–59 more than 30 lots of etheostomatine (darter) hybrid and control eggs were brought into the rodent colony room for survival studies. The rodent colony was much larger than when the previous experiments were carried out. The hybrids and controls of the new experiments all died within a day of hatching. These results were so discordant with previous survival (up to 70 percent average for most darters) that an artifact was suspected. Olfaction indicated the presence of ammonia, and led to the hypothesis that the physiochemical effect of the compound was a probable cause of the deaths. Hylid and etheostomatine eggs were placed in 26 × 38 cm. enamel rearing trays containing one gallon of water approximately 4 cm. deep. These eggs were tested in two ways. Some were placed in the room at various distances from the rodent colony. Others were placed above the white rats (the center of ammonia production as determined by olfaction) with water changes at regular intervals. All of them died. The time of death was correlated with the distance from the rodent colony and with the freshness of the rearing water, which had become contaminated with dissolved ammonia. Ammonia concentrations were ascertained by a colorimetric technique (Stone, *Proc. Soc. Exp. Biol. Med. 93:589–91*)[1]. For these and subsequent experiments, tadpoles of the fast trilling "race" of *Hyla versicolor* were used. Assorted young *Etheostoma lepidum, E. radiosum, E. spectabile, Hadropterus scierus, Percina caprodes,* and their hybrids were also used.

A pronounced increase in ammonia sensitivity was noted at hatching, so the experiments were repeated with young fish and newly hatched tadpoles. Similar results were obtained except that deaths occurred at lower ammonia concentrations, about 50 ppm. for the tadpoles and 30 ppm. for the darters (more than 100 ppm. were noted in a sample exposed to room air for less than 100 hours when the rodent cages had not been cleaned recently). These figures were observed at the time immediately following mortality. The animals had been subject to a rising ammonia solution rather than to a constant ammonia concentration. To determine if other air borne factors had been involved, artificial ammonia solutions were made up and the animals tested elsewhere. All tadpoles died within two hours in a 30 ppm. solution. In 15 and 7 ppm. solutions deaths were variable and took place after longer exposure intervals. Young tadpoles were apparently more susceptible than older ones. All darters died within two hours in 30 and 15 ppm. All died in 7 ppm. within four hours. All controls survived more than two days, as did those fish and tadpoles exposed to 3 ppm. In concentrations between 7 and 15 ppm. *Daphnia magna* were alive and healthy after several days exposure; all darters and some small tadpoles were dead in the same container. A few adult daphnia survived at 30 ppm. Apparently the susceptibility to ammonia poisoning is greatest in young darters, intermediate in tadpoles, and least in daphnia. The flatworm, *Dugesia tigrina,* appears to have an ammonia tolerance similar to that of large tadpoles. Other workers (Brockway, *Prog. Fish-Cult. 12:127–9,* 1950) have noted the toxic effects of ammonia on fishes; however, none stem from an air-borne source.

A few experiments have been reported that may have been adversely affected by ammonia poisoning in this room. Fouquette (1959, *Ph.D. dissertation, The University of Texas: vi + 73*) reported that Panamanian hylids did not survive in his work and following our experiments attributed the deaths to this phenomenon. Hubbs (*Texas Jour. Sci. 9:472–4,* 1957) reported low survival of hybrids after one of the parental gametes was exposed for various intervals to the water before fertilization. These fish were placed in this room after fertilization. As replications of the experiments did not show reduced survival, ammonia was undoubtedly the cause of the mortalities. Hubbs and Strawn (*Evolution 11:1–10,* 1957) reported extreme morphologic variability of F_1 hybrids. These fish were reared in this room but had moderately high survival. Hubbs (*Texas Jour. Sci. 8:463–9,* 1956) recorded similar results with other hybrids reared elsewhere. Thereby, these results were probably not affected by the ammonia contamination. It is possible that the "inhibitory products" reported by Richards (*Physiol. Zool. 31:138–51,* 1958) and Rose (*Science 129:1026,* 1959) are ammonia compounds.—CLARK HUBBS, MURRAY J. LITTLEJOHN[2] AND PATRICIA G. LITTLEJOHN[2], *Department of Zoology, The University of Texas, Austin, Texas.*

[1] The facilities of the Austin Clinical Pathology Laboratories were used for these determinations. We thank Drs. C. F. Pelphrey, T. G. Price, D. M. Queen, and J. R. Rainey for the free use of their laboratory.

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ADDITIONAL RECORDS FOR NEW FISHES IN CHESAPEAKE BAY.—Since the publication of recent records by Massmann (*Copeia 1957 (2):156–7*), four fishes new to Chesapeake Bay have been observed.

Etrumeus sadina (Mitchill). Round herring.—A single specimen (Virginia Fisheries Laboratory [VFL] 5772) was captured by trawl six miles southwest of Cape Charles, Virginia, in July, 1957.

Trachurops lathami Nichols. Rough scad.—A specimen (VFL 5481) was taken by trawl six miles southwest of Cape Charles in August, 1954. Another was trawled at the same location in July, 1957, and two more (VFL 58173) were caught five miles southeast of the York River mouth, Virginia, in June, 1958.

Scomberomorus cavalla (Cuvier). King mackerel.—Although the presence of this species in the bay had been reported by commercial and sport fishermen, the observations were not verified until September, 1958, when a 22-pound specimen was captured in a pound net at the York River mouth. Judging from the numbers captured by commercial pound-netters, king mackerel cannot be considered a rare fish in the bay.

Ammodytes americanus DeKay. Sand launce.—One (VFL 56230) was trawled eight miles west of Cape Charles in November, 1956.

Pollachias virens (Linnaeus). Pollack.—The single record listed by Hildebrand and Schroeder (1928, *Bull. U. S. Bur. Fish. 43:155–6*) was based on a note from W. C. Kendall who observed a pollack in a pound net catch made at Hampton, Virginia, in March, 1894. A second specimen (VFL 59183) was obtained from a pound net catch at Reedville, Virginia, in April, 1959.—WILLIAM H. MASSMANN, *Virginia Fisheries Laboratory, Gloucester Point, Virginia.* Contribution from the Virginia Fisheries Laboratory No. 90.

THE DEVELOPMENT OF THE ANTERIOR INTERHAEMAL CONE OF *EUCINOSTOMUS ARGENTEUS* BAIRD AND GIRARD.—All the western Atlantic species of Gerridae have the first and second interhaemal bones fused to form a single support for the first and second anal spines (Longley, *Carn. Inst. Wash. Pap. Tortugas Lab. Publ. 34 (535): 135*, 1941). The genus *Eucinostomus* is characterized by having these fused elements further modified into a cylindrical structure that opens anteriorly and which receives the posterior portion of the air bladder. In the past, there has been some confusion regarding the origin of this cone-shaped structure. Curran Doctoral Thesis, University of Michigan: 23–31, 1942) stated that Cuvier (Cuvier and Valenciennes, *Hist. nat. poiss.* 6: 465, 1830) and Günther (*Cat. fish. Brit. Mus.* 1: 347, 1859) believed that the cone was formed from the first interhaemal bone. Jordan (Jordan and Evermann, Bull. U. S. Nat. Mus., 47: 1367, 1898) believed that the second interhaemal bone gave rise to the structure. Parr (*Bull. Bingham Oceanogr. Coll., 3(4):61*, 1927) believed that the fused first and second interhaemals together formed the anterior structure of the interhaemal parts. Curran (*op. cit.*) described the mature interhaemal parts of the gerrids.

The object of this study is to describe the ontogenetic formation of the hollow, cylindrical anterior interhaemal cone in *Eucinostomus argenteus*.

Seventy-four specimens of *E. argenteus* ranging from 15 to 145 mm. in standard length were cleared and stained by the method outlined by Hollister (*Zoologica, 12(10):89–101*, 1934). At the completion of this process, the skeleton, stained a deep red, is easily distinguishable through the transparent tissues and can be examined in detail. In most cases, the anal fin with the interhaemal bones were removed from the fish in order to facilitate examination and to take photomicrographs.

The smallest specimens studied (15 mm.), and presumably the youngest, exhibited the most immature development of the interhaemal parts. The first and second interhaemals were already fused and the second interhaemal formed a posterior brace for the triangular, bladelike first interhaemal bone. This condition is illustrated in Figure 1-A. Figure 1-B illustrates the first appearance of the "cone" which develops as a slight elevation on the anterior margin of the first interhaemal bone (drawn from a 19 mm. fish) and eventually gives rise to two flanges, which grow away from one another and in contact with the postero-dorsal part of the air bladder (Fig. 1-C, 21 mm. fish). The flanges continue to expand and envelope the air bladder forming a receptacle that opens widest anteriorly and tapers to a slit more posteriorly (Fig. 1-D, 35 mm. fish). Eventually the flanges meet and fuse in the ventral midline and completely envelop the posterior portion of the air bladder (Fig. 1-E, 46 mm. fish). Figure 1-F is a drawing of the interhaemal cone of a mature *E. argenteus*. The air bladder (not shown in the figures) is inserted tightly into it, and pinched slightly at the point of insertion.

The anterior interhaemal parts of *Eucinostomus gula* develop in an identical manner, in that the cone develops from the first interhaemal bone, with the second interhaemal forming a posterior brace. These two bones are fused be-

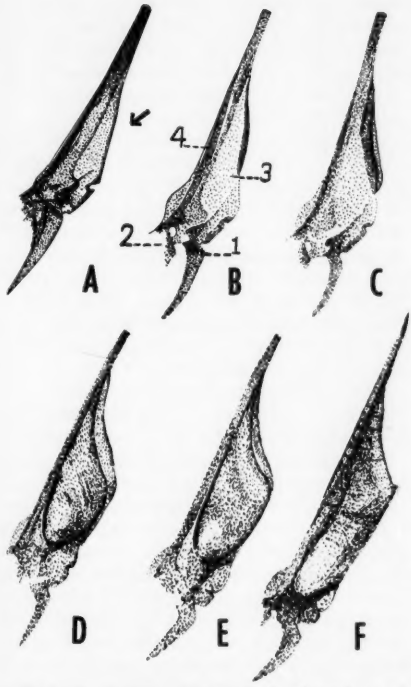

Fig. 1.—Development of the anterior interhaemal cone of *Eucinostomus argenteus*. The arrow points to the place of origin of the cone on the first interhaemal bone (first and second interhaemals fused). 1. First anal fin spine. 2. Second anal fin spine. 3. First interhaemal bone. 4. Second interhaemal bone. Drawings made by Ralph Freeny from author's sketches.

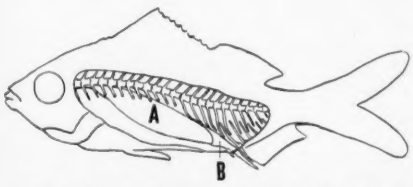

Fig. 2.—Diagram showing the intimate relationship between the air bladder (A) and the interhaemal cone (B) in *Eucinostomus argenteus*.

fore the cone develops. The cone has a greater curvature and the anterior aperture is wider and does not greatly constrict the air bladder as in *E. argenteus*.

The function of this peculiar modification is not known at the present time. However, the intimate association of the interhaemal bones and air bladder (Fig. 2) suggests that it may be involved in auditory functions since it resembles a resonator. This could be either in sound reception or conduction. Experiments are in progress in order to determine whether or not it has an auditory function.

The author is indebted to Dr. Giles Mead for calling attention to this problem and for providing numerous specimens. I would like also to express my gratitude to Dr. Leonard P. Schultz, Dr. William Sutcliffe, Jr., and Mr. Clarence L. Smith for their aid in obtaining specimens. Dr. Howard E. Winn kindly read the manuscript and offered many helpful suggestions in its preparation.

This investigation was supported in part by research grants from the Public Health Service (B-1668) and the Office of Naval Research (N.R. 104–489).—ANTHONY PICCIOLO, *Department of Zoology, University of Maryland, College Park, Maryland.*

A HIGH INCIDENCE OF THE HYBRID *ACROCHEILUS ALUTACEUM* × *PTYCHOCHEILUS OREGONENSE*.—In 1957 and 1958, 19 hybrid cyprinids of the parentage, chiselmouth, *Acrocheilus alutaceum*, × squawfish, *Ptychocheilus oregonense*, were collected in the Yakima River, Washington State, by the U. S. Fish and Wildlife resident fish studies staff, Seattle Biological Station, Bureau of Commercial Fisheries. Eight of these were taken in the Prosser power diversion ditch by-pass trap near Prosser, Washington, on October 15–16, 1958. The other 11 were discovered in electro-fishing collections from the Yakima River during 1957 and 1958.

The chiselmouth × squawfish hybrid is not common, as determined by extensive electro-fishing throughout the Yakima River. Completed data on these collections show 11 hybrids of this parentage out of a total of 23,400 fish, of which 4,260 were chiselmouth and 2,000 squawfish. The high occurrence of the hybrid at the Prosser fish trap warrants reporting.

Previous descriptions of this hybrid were made from two individuals, one taken in the Willamette River near Corvallis, Oregon (Snyder *Bull. U. S. Bur. of Fisheries, 27(1907):153–189,* 1905) and the other from a tributary to the Snake River near King Hill, Idaho (Hubbs and Schultz, *Occ. Papers Mus. Zool. Univ. Mich. (232):1–6,* 1931). To corroborate the identification of the chiselmouth × squawfish hybrid and to extend knowledge about this hybrid, data from the Yakima River specimens are included.

Prosser trap collection: Eight hybrids were collected in an inclined-screen fish trap, installed to collect fishes by-passed back to the Yakima River from the Prosser power-diversion ditch. The trap was in operation for two successive days to collect scrapfish for laboratory experi-

Fig. 1.—Three chiselmouth (*Acrocheilus alutaceum*) X squawfish (*Ptychocheilus oregonense*) hybrids, showing the characteristic head and mouth.

TABLE I

COMPARISON OF DIAGNOSTIC CHARACTERS OF THE CHISELMOUTH (*Achocheilus alutaceum*) X SQUAWFISH (*Ptychocheilus oregonense*), ITS PARENTS AND THE REDSIDE DACE (*Richardsonius balteatus*)

Characters	Species			
	Ptycho-cheilus	Hy-brids	*Acro-cheilus*	*Richard-sonius*
Number examined	14	14	10	9
Rays in dorsal fin				
Range	10	10–11	11	10–12
Average	10	10.8	11	10.7
Rays in anal fin				
Range	9–10	9–10	10	14–17
Average	9.9	9.8	10	15.7
Vertebrae				
Range	44–46	43–46	45–48	41–42
Average	45.2	44.9	46	41.7
Scales in lateral line				
Range	69–76	75–86	86–94	55–63
Average	71.9	80.2	90.3	58.2
Scales above lateral line				
Range	14–19	15–22	21–27	11–13
Average	16.1	18.4	23	12
Scales below lateral line				
Range	8–12	8–15	13–16	6–9
Average	10	10.8	13.9	7.1

ments. Fish movement into the trap was almost entirely at night and is indicative of a downstream migration. Scale examination of a five-fish sample of the hybrids with a range of 185 to 205 mm. fork length indicated them to be fish that had lived two winters.

Four species of fishes and a crayfish were trapped with the hybrid. There was a heavy downstream movement of largescale suckers, *Catostomus macrocheilus*, all approximately 200 mm. long. Other incidental fishes were chiselmouth, largemouth bass, *Micropterus salmoides*, and the brown bullhead, *Ictalurus nebulosus*. About one-half of the trapped fishes were released without examination. Upwards of 4,000 crayfish, *Pacifastacus klamathensis*, also moved into the trap during one night.

Electro-fishing collection: Eleven hybrids were discovered among electro-fishing collections from the Yakima River. The hybrids were taken at various locations between the mouth and the town of Yakima, 100 miles upstream. The size range of these fishes is 70–287 mm. fork length.

Verification of hybridization: The squawfish and chiselmouth are considered the parents because of the intermediate characteristics of the hybrid to these fishes (Fig. 1) and lack of resemblance to other possible cyprinid parents in the Yakima system. The Yakima cyprinids include carp, *Cyprinus carpio*, peamouth chub, *Mylocheilus caurinum*, chiselmouth chub, squawfish, Columbia redside shiner, *Richardsonius balteatus*, longnose dace, *Rhinichthys cataractae*, Columbia River dace, *R. falcatus*, and speckled dace, *R. osculus*. The peamouth is rare in the Yakima system and offer little chance of hybridization. The three daces are small and do not occupy the same habitat as adult squawfish and chiselmouth. Carp are not known to hybridize with indigenous cyprinids. Redside shiners do not resemble the hybrids in most characters (Table I).

Meristic counts from a sample of the suspected parent species from the Yakima River are compared with the hybrids from electro-fishing and Prosser trap collections in Table I to demonstrate intermediacy. The counts followed the methods outlined by Hubbs and Lagler (*Bull. of Cranbrook Institute of Science, 26:8–13*, 1949). Fin ray and vertebrae counts were made from X-ray photographs.

Examination of principal characteristics usually revealed intermediacy. The angle of the maxillary of the squawfish is straight (180°), the chiselmouth's is decurved (130–140°); in the hybrid, the maxillary is decurved (150°). The jaw of the chiselmouth is a rectangular, hard, carti-

laginous plate. The jaw of the hybrid and squawfish is rounded without hardened cartilaginous parts. The peritoneum of the chiselmouth is jet black. In the squawfish the peritoneum has little pigmentation. Peritoneum pigmentation in the hybrid is variable between that of the parents. The alimentary canal of the hybrid is "S" shaped, as in the squawfish. This differs from the convoluted chiselmouth intestine. Parasitism of the buccal cavity by hirudineans, which is prevalent in the chiselmouth and reduced in the squawfish of the Yakima River, occurs in the hybrid.

The Yakima River chiselmouth × squawfish is apparently identical with *Leuciscus caurinus*, described by Snyder (*op. cit.*) and correctly identified as a hybrid by Hubbs and Schultz (*op. cit.*). Also, it is the same as the hybrid collected near King Hill by the latter authors.

The abundance of Yakima River examples imply that the chiselmouth × squawfish hybrid is not as rare as past records indicate. They can easily be misidentified as chiselmouth by persons inexperienced in squawfish and chiselmouth characteristics. Investigators working in the lower Columbia River have reported a fish that appeared to be a chiselmouth × squawfish hybrid, but unfortunately none could be obtained to verify this identification.—BENJAMIN G. PATTEN, *U. S. Bureau of Commercial Fisheries, Biological Laboratory, 2725 Montlake Blvd., Seattle 2, Washington.*

MARINE FISHES COLLECTED FROM INLAND STREAMS OF ALABAMA.—Fishes which are usually associated only with salt or brackish water are occasionally collected from freshwater streams at considerable distances from the sea. The striped mullet, *Mugil cephalus* Linnaeus, has been reported 274 miles inland on the Colorado River, Texas, by Gunter (*Copeia (2):69–72,* 1938) and in the Red River, Bryan County, Oklahoma, by Riggs (*Copeia (2):158,* 1957). Fishermen have observed mullet in the Coosa River at Wetumpka, Alabama, for the past five or more years (Byrd, *Alabama Conserv. 26(1):3, 26,* 1954).

In June, 1953, a mullet 15 inches total length was collected from the Cahaba River near Centerville, Alabama. At this point, the river is 227 feet above sea level and 377 miles by water course from the Gulf of Mexico.

Other euryhaline fishes found upstream in the rivers of Alabama are the needlefish, *Strongylura marina* (Walbaum) and the hogchoker, *Trinectes maculatus* (Bloch and Schneider). A needlefish was caught in the Black Warrior River at Tuscaloosa, a point 388 miles by water course from the Gulf, and another was taken from Big Sandy Creek, a tributary of the Black Warrior River two miles south of Hull, Tuscaloosa County, Alabama. Hogchokers were collected from the Tombigbee River, 18 miles south of Jackson, Alabama, and from the Escambia River near Brewton, Alabama. These localities are about 95 and 80 miles respectively by water from the Gulf.

The occurrence of the needlefish this far inland apparently constitutes a distance record for upstream migration of the species.

The specimens mentioned herein are deposited in the University of Alabama Ichthyological Collection.—HERBERT T. BOSCHUNG, *Department of Biology, University of Alabama, University, Alabama,* and A. F. HEMPHILL, *Department of Biology, Spring Hill College, Mobile, Alabama.*

EULEPTORHAMPHUS OFF LONG ISLAND, NEW YORK.—Through the kindness of Mr. Arthur Cooley of Quogue, New York, we received a freshly preserved specimen of *Euleptorhamphus velox* Poey from that locality (AMNH 20402). It was found on the beach, August 7, 1959, evidently newly dead at the Surf Club of Quogue. The standard length measures 238 mm., the length to tip of lower jaw, which is not quite complete, 333 mm., and over-all length 365 mm. This is evidently a hitherto unrecorded species for the state. There are two records from further north where the Gulf Stream is closer to the coast; Newport (Sumner, Osburn and Coles. *Bull. U. S. Bur. Fish.* 31 (pt. II): 745, 1913); and off Nantucket (Putman. *Proc. Boston Soc. Nat. Hist.* p. 238, 1871). The nearest record to the south of New York appears to be that of Cope (*Proc. Acad. Nat. Sci. Phila.* p. 121, 1870) for Atlantic City, New Jersey, which is mentioned by Fowler (1905, *Rept. N. J. State Mus.* p. 203–10) and presumably the fish figured by him (1906, *Ibid.* pl. 94).

For the last several summers more than the usual numbers of southern fishes have been reported or brought to the Museum by the public, but these have all been, with the present exception, representatives of species which appear each year in some numbers. This seems to be in accordance with the general warming and more northward ranging of marine life along our north Atlantic coast.—C. M. BREDER, JR., *The American Museum of Natural History, New York, 24, N. Y.*

UTILIZATION OF NESTS OF LARGEMOUTH BASS, *MICROPTERUS SALMOIDES*, BY GOLDEN SHINERS, *NOTEMIGONUS CRYSOLEUCAS*.[1]—During recent studies (Ding-

[1] Paper No. 1025 Miscellaneous Journal Series, Minnesota Agricultural Experiment Station, St. Paul 1, Minnesota

ell-Johnson Project F-12-R) at Lake George, Anoka County, Minnesota, golden shiners, *Notemigonus crysoleucas* (Mitchill), were observed spawning in nests of largemouth bass, *Micropterus salmoides* (Lacepede). In the three-year period, 1956–1958, when samples of bass eggs were taken, it was found that four to 75 percent of the active bass nests in the lake proper and 40 to 94 percent of those in an adjoining slough were used by golden shiners for egg deposition. The percentage of golden shiner eggs in nests used by shiners ranged from 0.6 to 78.4 percent of all eggs present.

Spawning of golden shiners was observed in 1957 and 1958 when schools of 25–100 fish deposited eggs in bass nests 1–2 days after the bass had spawned. In 1957 the male bass guarding the nest did not interfere with the spawning activity of the shiners, but in 1958 he attempted to drive them away by repeatedly charging into the spawning group. No explanation was apparent for this variation in behavior, but the pattern was consistent for all fish observed each season. The golden shiners did not select any particular one of the four bottom types used by the bass for nest construction (mats of infertile needlerush, *Eleocharis acicularis*, humps of fibrous organic debris, pits dug into the bottom to a fibrous substrate, and bare sand).

The young shiners rose from the nest either a day before or on the same day as the young bass. Both groups, however, remained separate with the shiners swimming just below the water surface while the bass remained near the bottom for a few days before beginning to forage at all depths in the nursery area. Shortly before the bass broods dispersed, solitary or small groups of bass (five or less) were observed following broods of golden shiners. It was thought that these were bass that had become separated from their original brood and had joined the golden shiners. The behavior of these bass fingerlings, however, was much different than that displayed by those in bass broods, for these bass gave the appearance of actively "herding" the shiners and would occasionally nip at their tails. When a scap net was lowered into the water the bass drove the shiners away, faced the net, and were easily captured in the net. Since both species were about the same length when they rose from the nest and their growth rates were similar, there was insufficient size differential to permit the use of one by the other for food. Richardson (*Bull. Ill. Nat. Hist. Surv.* 9(8): 405–16, 1913) reported that bass fingerlings about 1-½–2-½ inches in length sought protection in schools of golden shiners. The bass at Lake George, however, were less than 1-½ inches total length and did not appear to be seeking protection. Moreover, this "herding" activity was observed only in 1955 and 1957, and not in 1956 and 1958.

Golden shiner reproduction was the greatest in successful bass nests, and the least successful in bass nests which failed to give rise to a brood. Shiner eggs laid in prepared but unused bass nests disappeared shortly after spawning. Abundance of young-of-year golden shiners, as determined from bag-seine catches during the summer, was directly proportional to the percentage of bass nests utilized for spawning in the spring.—ROBERT H. KRAMER AND LLOYD L. SMITH, JR., *Department of Entomology & Economic Zoology, University of Minnesota, St. Paul 1, Minnesota.*

TOXICITY OF THE SPOTTED NEWT, *NOTOPHTHALMUS VIRIDESCENS*, TO TROUT.—The spotted newt, *Notophthalmus viridescens*, is abundant in many waters of the Adirondack Mountains of New York State. Many of these streams are also inhabited by brook trout, *Salvelinus fontinalis*. Cursory observations on the stomach contents of several hundred trout from these waters over the past ten years have failed to disclose the ingestion of a single newt, although ecologically this salamander is readily available to the fish. Absence of newts from the diet of trout in general seems to be the rule within the writer's experience, although some recently planted brown trout, *Salmo trutta*, from Six Mile Creek, New York, had eaten a few specimens (Webster and Little, *Copeia* 1942 (*3*):*192*); Cooper (*Maine Dept. Inland Fish. and Game, Fish Surv. Rept.* (*5*):*109* 1942) reported three newts among the stomach contents of 133 brook trout examined from eight Maine ponds and lakes.

Observations reported here were prompted by the collection of a recently dead "tiger" trout (hybrid *S. fontinalis* × *S. trutta*) in Green Lake located on the Adirondack League Club near Old Forge, New York. This specimen appeared in perfect health but its stomach contained a recently ingested newt.

In early May 1959, eight wild brook trout, 7–11 inches in length, were force-fed each with one newt. Previous to feeding, specimens were anesthetized with urethane or MS222. Two of the fish, 10–11 inches long, were dead in one and one-half hours, and a third was moribund. Smaller fish, 7–8 inches long, showed acute convulsive distress and loss of equilibrium within 5-10 minutes, and all died shortly afterwards. One of the ingested newts was in the red eft stage. As a control, a specimen was fed a small chub and the trout remained in healthy condition.

Another series of observations with hatchery-reared trout in a hatchery trough indicated

clearly that the newts were distasteful or at least unacceptable in some form if the trout could make the choice in feeding. Trout that would take artificial food out of the hand seized a newt fed to them, but quickly rejected it. Often a newt was rejected several times by the same fish. In no case was a newt actually ingested.

The western newt is rarely eaten by either birds or mammals, probably because of the poisonous properties of the skin glands, according to Noble (*Biology of the Amphibia, McGraw-Hill, 1931*), and this condition may also hold for the eastern form. It is interesting to speculate how trout "learn" that these organisms are not suitable for food. Presumably each individual trout may have an experience which leads it to reject the newt as a suitable food item. Otherwise these limited feeding tests suggest that an immediate death is inevitable.—DWIGHT A. WEBSTER, *Department of Conservation, Cornell University, Ithaca, New York.*

STARKSIA OCELLATO (STEINDACHNER), A NEW SPONGE INQUILINE FROM SOUTH CAROLINA.—On February 25, 1958, an *Ircinia*-type sponge, approximately 12 inches in maximum diameter, was trawled in 13 fathoms southeast of the North Edisto River, South Carolina, by the Bears Bluff Laboratories' vessel, M/V T-19. The sponge was dissected while still fresh and four small blennies, subsequently identified by Dr. David Caldwell as *Starksia ocellata* (Steindachner), were found lodged within the canal system. Standard lengths of 24.5, 32.1, 32.5 and 35.4 mm. were recorded. The blennies occurred in pairs in separate and apparently unconnected canals. Each canal opened to the outside of the sponge and appeared to be of sufficient interior diameter to permit normal swimming activity.

Longley and Hildebrand (*Papers Tortugas Lab. 32:258–9*, 1941) found *S. ocellata* common among corals and sea-urchins at Tortugas, but no mention is made of its occurrence in the abundant sponges of the area. Gudger (*Zoologica 35(2): 121–6* 1950) listed 13 species as sponge inquilines. *S. ocellata* constitutes the fourteenth species and third blenny, including *Paraclinus marmoratus* (Steindachner) and *Starksia cremnobates* (Gilbert), known to occur in sponges.

Briggs (*Bull. Fla. State Mus. 2(8):291*, 1958) recorded *Starksia ocellata* as distributed from the Bahamas and southwestern Florida to Brazil. The present specimens represent a northerly range extension of some 500 miles.

Two specimens have been deposited in the collections of the University of Florida (UF-7270) and the remaining specimens are in the collections of Bears Bluff Laboratories, Wadmalaw Island, S. C.—C. E. DAWSON, *Gulf Coast Research Laboratory, Ocean Springs, Mississippi.*

REVIEWS AND COMMENTS

PHYLAX TELESCOPUS

That *Copeia* has long outgrown the status of a provincial organ of a purely national society has occurred to the new Editors, and in a laudable but possibly over-sanguine effort towards broader coverage they have seen fit to ask the undersigned to contribute the present column. Other than the suggestion that we concern ourselves primarily with exotic and possibly esoteric goings-on in the ichthyological and herpetological world, Dr. Jameson and his two able co-editors have given us *carte blanche*. Our interpretation is that we are expected to supplement the offerings of the *Reviews and Comments* section, which has traditionally concentrated on formal reviews to the exclusion of comments. However, the Editors do gently suggest a trial run for the year 1960, possibly in the doubt that either columnist or readers can endure the experience for more than four issues. Finally, in an informal approach to literature and events, it seems worth-while to make it perfectly clear that opinions expressed are those of the columnist, not those of the Editors, of *Copeia*, or of the ASIH.

In the Soviet scientific bureaucracy, it is evident that economic considerations outweight the call of either personal interest or pure science. Ichthyology, which even politicians know deals with creatures of great economic importance, is greatly favored over herpetology, which deals only with what bureaucrats would call vermin. Herpetology has languished in Soviet Russia. It is thus of interest to note the recent appearance of some beginnings in this field in the Soviet Union, where the herpetological works of Pallas, Eichwald, Strauch, Bedriaga, and A. M. Nikolski once took an honored place in Russian science.

The most extensive recent paper we have seen is Iskakova's *Amphibians of Kazakstan*. (Zoological Institute of the Academy of Sciences of the Kazakst S. S. Republic, Alma-Ata, 1959: 91 pp. [In Russian.]) This is a straight faunal handbook of the three urodeles and eight salientians so far recorded from an area over four times the size of Texas, extending from the Volga River to the Altai Mountains of Central Asia. Accounts of life history and larvae are given where known, and there are spot-maps of distribution. The map for the commonest and most widespread Central Asiatic amphibian, *Bufo viridis*, would indicate that amphibian collecting in Kazakstan has been extensive. However, it is difficult to believe that all of the species, especially of salamanders, have been found, despite the fact that Kazakstan has perhaps the poorest amphibian fauna of any major land area of the world outside the truly frigid regions. The salamander map on p. 13 shows only a single record for *Hynobius keyserlingi* in the far north, towards Omsk, three records in the Altai region for *Ranodon sibiricus*, and two doubtful records for *Triturus vulgaris* from the Aral Sea and Lake Balkash areas. We suspect that a good American salamander collector could change the picture.

Bombina bombina and *Pelobates fuscus* are recorded only in western Kazakstan, and *Bufo bufo* only along the northern borders, while *Rana chensinensis* (=*amurensis*) enters only on the southeast. *Rana arvalis* (for which the author uses the preoccupied and invalid name *R. terrestris* Andrzejowski) is common in northern Kazakstan. However, the distribution given for *R. ridibunda*—the Uralsk drainage in the northwest and the Syr-darya, Iti, and other drainages in the southeast—seems peculiar. Finally, it would appear that the author's literature sources, save for one old paper by the German ornithologist Finsch, were entirely Russian.

Some of our respected ichthyological colleagues have lately displayed great diligence in determining which of the new species in Cuvier and Valenciennes' *Histoire Naturelle des Poissons* are to be credited to Cuvier and which to Valenciennes. The remarkable conclusion has been advanced that no parts of an avowedly joint work were in fact joint, and that all new species must be assigned either to Cuvier or to Valenciennes. We regard such a conclusion with suspicion, especially in regard to the volumes which appeared while both authors were living and contributing to the work. Moreover, if M. Valenciennes wished to continue ascribing co-authorship to his revered master after the latter's death, we feel that later workers should respect his obvious desire, especially since few of them can have any first-hand knowledge of the authorship of any part of the original manuscript. If, however, such sticklers for nomenclatural accuracy wish further occupation, we have some suggestions. It is obvious that most of the additions to Bloch made by "Bloch and Schneider" (1801) were by Schneider alone, and some soul might busy himself changing the authorship of all "Bloch and Schneider" names. Bringing things nearer home, it is well known that all of the three volumes on *The Marine Fishes of Panama*, as well as the single one on *The Fishes of the Fresh Waters of Panama*, generally ascribed to Meek and Hildebrand, were in fact written entirely by the junior author. Much the same can be said for the first three volumes of *Fishes of the Philippine and Adjacent Seas* by Fowler and Bean; Bean had nothing to do with the actual research and writing. Moreover, that is not the end. The larger part of Jordan and Evermann's *Fishes of North and Middle America* was done by Jordan and Gilbert, Evermann having acted chiefly as editorial compiler after Gilbert disassociated himself from formal authorship. The major part of Jordan and Evermann's *Shore Fishes of the Hawaiian Islands* is said to have been done by H. W. Fowler, while possibly large sections of Jordan and Seale's *Fishes of Samoa* were the work of Jordan and A. W. Herre, who was forced, for economic reasons, to relinquish co-authorship when he left Stanford. Other similar instances could be cited. Are not these, and the numerous "new species" involved, quite as needful of authorial revision as the work of Cuvier and Valenciennes? Personally, we shall continue to quote all 22 of the volumes of the *Histoire* as by Cuvier and Valenciennes.

The most extensive Japanese ichthyological work to reach us lately is Prof Masao Watanabe's *Studies on the Cottid Fishes of Japan*. (Tokyo: 461 pp., 124 pls. 1958. [In Japanese]) However, few workers outside Japan will make any attempt to use it or pay any attention to the author's results, simply because the entire work is in Japanese. As we pointed out long ago (*Copeia*, 1952:57–58) zoological work now appears in far too many languages for a zoologist to bother with Japanese. Moreover, we are unable to comprehend why a general work devoted to Japanese cottids should omit definitely established Japanese genera and species (*e.g., Astrocottus leprops; Atopocottus tribranchius*) from both text and keys.

A much different type of systematic work is represented by Ishiyama's excellent monograph of Japanese skates (Ishiyama, Reizo. *Studies on the rajid fishes (Rajidae) found in waters around Japan*. J. Shimonoseki Coll. Fisher., 7(2):188–394,

3 pls. 1958 [In English.]) Careful attention is given to the systematically important structure of the claspers, and extensive measurements of considerable series of specimens are presented. The number of distinct Japanese species was found to be much higher than expected, Dr. Ishiyama himself having described 11 of the 24 species recognized, six of them in the present paper.

At this place we cannot pass over without remark the most important work in systematic ichthyology ever to appear in Japan. Although the first volume of Prof. Matsubara's *Fish Morphology and Hierarchy* (Matsubara, Kiyomatsu. *Fish morphology and hierarchy*. Ishizaki-Shoten, Tokyo: 3 vols., 1600 pp., 536 text-figs., 135 pls. 1958. [In Japanese.]) was briefly reviewed in *Copeia* by Walters and Robins, and the second and third barely mentioned (*Copeia*, 1956: 66, 134), the work deserves added comment. It was clearly intended to bring the classification of Japanese fishes into line with the latest ichthyological research—and thus to wipe out the provincial ignorance of world literature in which some Japanese ichthyologists had labored. In accomplishing this task, Prof. Matsubara produced what would be, if it had been written in English, French, or German, a treatise equal to or surpassing Berg's *Classification of Fishes* in practical usefulness to ichthyologists everywhere. Even in the Japanese text, the obvious arrangement of genera, the anatomical illustrations, and the wealth of recent world literature cited after every major group treatment, make the work one which we find it necessary to consult quite as often as Berg. Although in most instances only the Japanese genera and species have been keyed out, the treatment is often of broader range, and the richness of the Japanese fish fauna makes the contribution especially useful to workers on marine fishes everywhere. Unfortunately, like Berg's, the work is marred by the utilization of a system of group names not of general currency, in this instance the so-called "Stenzel system."

Of all nations, money for expensively done zoological publications seems to flow most freely in Belgium. This is especially noticeable in anything having to do with the Congo. While we welcome such recognition of the importance of scientific work in a colonial area, the frequent wasting of publication money through carelessness and poor editorial supervision of many Belgian publications would cause any zoological editor outside Belgium to wince. (An example, chosen purely at random, and by no means as bad as many we have seen, occurs in Ann. Mus. Roy. Congo Belge, ser. 8vo zool., vol. 71, pp. 118–119. The data there recorded for two species of *Protopterus* could have been given in one-third the space and type utilized.) Moreover, such wasteful methods of presentation may leave both authors and editors open to the charge of padding their publications.

One extensive Belgian publication which is better edited than most, and which has not yet been noticed in *Copeia* is the first installment of of Dr. Laurent's contribution to the herpetology of the region of the Central African lakes. (Laurent, R. F. *Contribution à l'herpétologie de la region des grandes lacs de l'Afrique centrale*. Ann. Mus. Roy. Congo Belge, ser. 8vo, zool., vol. 78, 390 pp., 31 pls. 1956.) This comprises the introduction and the reports on the turtles and snakes. The collections upon which it was based were extensive and the novelties relatively numerous. For example, the discovery of two distinctive new vipers, one of them (*Atheris hispida*) perhaps the most remarkably rough-scaled snake known, is an indication. Perhaps the most generally useful parts of the work are the keys to the testudinates and snakes of the region of the Great Lakes of Africa.

Another useful recent publication on African herpetology is Villiers' handbook of the chelonians and crocodiles of "French Black Africa." (Villiers, A. *Tortues et crocodiles de l'Afrique Noire Française*. Institute Française d'Afrique Noire, Initiations Africaines, no. 15, 354 pp. Dakar, 1958.) This is the latest of a series of semipopular treatises on the biota of French Black Africa (which excludes Algeria), and it is one of the best of them. It is well illustrated (290 figures), contains much information on habits, life histories, and anatomy, ends with a good bibliography, and (unlike so many French works) actually has an alphabetical index—at least to scientific names. The author shows acquaintance with most of the pertinent foreign literature, and the treatment is both adequate and admirable for a work of its sort.

The fishes of New Guinea are very poorly known, and the appearance of Ian Munro's checklist (Munro, Ian S. R. *The fishes of the New Guinea region*. Territory of Papua and New Guinea (Port Moresby), Fisheries Bull. No. 1 (reprinted from the Papua and New Guinea Agricultural Journal, vol. 10, no. 4): pp. 97–369, 1958.) fills an important gap. The area treated includes Waigiu, the Bismarck and Louisiade Archipelago, and the westernmost of the Solomons. The checklist is a bibliographic one, with known records included, and 1429 species are listed. That so small a number is known from an immense area amidst the richest of all marine fish faunas underlines how poorly we know the marine resources of the world. In general, the author seems to have been aware of late revisional work, and

relatively few species recorded from the area are omitted. Among them are *Corythoichthys ocellatus* Herald 1953 and *Remilegia australis*, the latter known from the north coast of New Guinea. The work has an excellent index.—G. S. Myers, Stanford University, Stanford, Calif.

REPTILES AND AMPHIBIANS OF THE SAN FRANCISCO BAY REGION. By Robert C. Stebbins. University California Press, 1959: 72 pp. $1.50.—Another publication in which Dr. Stebbins continues to popularize the study of herpetology, this book contains accounts of the herpetofauna of that portion of California surrounding San Francisco Bay, with emphasis on the living organisms, their habits and habitats. Full advantage is taken of the author's artistic talent for the small guide is illustrated with twenty-five black and white figures, mostly new, but some taken from earlier papers, and eight color plates that include 39 of the 41 species known from the area. Both the text and illustrations are generally excellent within the space limitations.

Several points detract from the otherwise thorough and popular coverage. Description of first-aid for snake-bite is absent, with two references to other publications for such information. Since the guide is likely to serve in the field, this omission is a serious one. The book, by its very nature provincial, seems overly so as five species (*Ambystoma tigrinum, Rana catesbeiana, Phrynosoma coronatum, Cnemidophorus tigris* and *Hypsiglena torguata*) listed as occurring only in the east bay are known to range at least as far north as southern San Mateo County on the west or peninsula side of the bay. The last three species seem to be restricted in the west bay area to scattered islands of chaparral that lie between the redwood forest and oak woodland zones. Finally, the legless lizard *Anniella* is known from near San Jose in addition to the listed localities.—Jay M. Savage, *University of Southern California, Los Angeles 7, California.*

THE SEA-HORSE AND ITS RELATIVES. By Gilbert Whitley and Joyce Allan. Melbourne, Australia; Georgian House; 1958; x + 84 pp., colored frontispiece, 24 figs; cloth; 30 shillings.—This little book is concerned principally with the strange fishes of the order Solenichthyes, with especial reference to the Australian forms. The seahorse part deals with lore and legends, habits and breeding, structure, the Australian seahorses, and a checklist of specific names applied to species of the genus *Hippocampus*. Following, there are chapters on leafy sea dragons, on links between pipefishes and seahorses, on pipefishes, and on flutemouths, centriscids, and pegasids. Finally, there is a short bibliography and an index.

The book collects a good deal of scattered and useful information. However, it appears to be addressed to non-ichthyologists, to whom many of the technical details will be of little use. Yet the ichthyologist, or even an aquarist who wishes to keep seahorses alive, will find the book exasperatingly incomplete. Reference is made to the difficulty of keeping seahorses alive, or breeding them, but there is no mention of feeding with brine-shrimp nauplii from eggs now commercially obtainable anywhere. The taxonomy is of the Whitleyian variety, in which classification is not a science but an art—a kind of ichthyographical necromancy in which species and especially genera are made to materialize at will, but often vanish into thin air whenever a cold, unfeeling ichthyologist attempts to investigate their ectoplasmic substance. The bibliography also has its nettling lacunae, for example Herald's fine revisional work on Indo-Pacific syngnathids in Schultz's Bikini report (1953) and Rendahl's review of the pegasids. —George S. Myers, *Natural History Museum, Stanford University, Calif.*

LES GENRES DES POISSONS D'EAU DOUCES DE L'AFRIQUE. By Max Poll. Annales du Musée Royal du Congo Belge, ser. in 8vo, sci. zool., vol. 54, 191 pp. Tervuren, Belgium, 1957.—Since the publication of Boulenger's four-volume monograph of African freshwater fishes, (1909–1916), the African freshwater fish fauna has been the subject of exceedingly active systematic research. Revisional studies by Regan on the cichlids and the freshwater clupeids, and by the present reviewer on the cyprinodonts, have completely changed Boulenger's generic arrangement and nomenclature. The extensive revisional work of Trewavas and Greenwood on the cichlids; of Poll on the Congo fauna; of Regan, Worthington, Ricardo, Poll, Greenwood and others on the lake fishes; of Barnard on South African forms; and of Pellegrin, Holly, Monod and Daget on French West African fishes, has made most of Boulenger's great monograph far out-of-date, but there has been nothing to replace it.

Under these conditions, Dr. Poll's modern synopsis of the genera of the fresh-water fishes of the African continent, with references to the recent literature, is an important piece of work. It becomes, in fact, the new point-of-departure for subsequent studies of African freshwater fishes, and its practical value is exceedingly great.

The work begins with a tabular list of the families and genera, followed by sections on the characters of the families, general geographical distribution, distribution of Congo Basin fishes,

and methods of measuring and describing. Then comes a key to families, and finally, keys to the genera of each family. The keys are illustrated by figures of one species of almost every genus, and special figures of dentition and other key characters. Finally, there is the bibliography, and alphabetical indexes to the figures and to scientific names.

It would be remarkable if a work of such a comprehensive nature were completely free of errors, at least to the eye of specialists. In the Osteoglossidae, *Heterotis* still appears; it was shown to be a synonym of *Clupisudis* in 1919 by Jordan. The family Cromeriidae and the genus *Cromeria* still stand without question despite this reviewer's suggestion (1938, Smithsonian Report for 1937: 344, 349, footnotes 3, 16) that *Cromeria* is a young (or neotenic) *Kneria*. *Mochokus* and the family *Mochokidae* are misspelt. In the cyprinodontids, the figure of *Procatopus* (pl. 31, fig. 268bis) has no legend. Moreover, Fowler's genus *Lembesseia* is not keyed out but is apparently accepted in good faith; it is obviously an introduced or mislabelled American fish of the family Poeciliidae, probably *Poecilia vivipara*. (Such introductions (if this represents one) are increasingly to be expected. See Myers, 1940, Copeia, no. 4:267.) There may be differences of opinion in regard to some other of Dr. Poll's usages, for example *Hydrocyon* for the earlier *Hydrocynus*, *Ichthyoborus* for *Ichthyborus* (in any event a preoccupied name, for which *Ra* is apparently correct), the retention of *Neolebias* (which Dr. Trewavas thinks cannot be separated from *Nannaethiops*), and the separation of the families Characidae and Citharinidae, each of which may contain aggregations variously related to certain possibly annectent South American groups. Finally, the author has apparently not been aware of some recent revisional work on the Syngnathidae *(e.g.,* Herald, 1953, *in* Bull. U.S. Nat. Mus., 202: 231–278) or of the fact that some genera of tropical syngnathids (*Belonichthys, Oostethus*) are freshwater fishes.

Despite these points, there is no doubt that Dr. Poll has done an excellent job in smoothing the way for future workers on the systematics of African freshwater fishes.—GEORGE S. MYERS, *Natural History Museum, Stanford University, Calif.*

THE FRESHWATER FISHES OF CANADA. By E. P. Slastenenko. Kiev Printers, Toronto, 1958. 385 pages. $15.00—This book is a compilation of information on 185 forms of fish, and includes keys, synonymies, illustrations, descriptions, and notes on distribution and life-history. Sections introducing the families include excerpts from works by Berg and by Jordan and Evermann. Keys to the species vary in quality, some containing several internal contradictions. The standard of printing is not high; typographical errors are numerous, and most species descriptions are accompanied by illustrations which have been reproduced rather unsuccessfully from other works. Figures 82 and 85 are not based on the species they purport to illustrate. A table of distributions at the back of the book contains some evident contradictions. The author has in most cases used conservative nomenclature, particularly at the subspecific level. Unusual items include use of *Baione fontinalis* (Mitchill) for the brook trout. The author also recognizes *Cristivomer siscowet* (Agassiz) as a species distinct from *C. namaycush*, a decision based on personal study. Unfortunately for his treatment of most of the other species, he has lacked permanent association with any North American museum or university where he could gain first-hand experience with the fauna. Accordingly most of the book has been compiled indiscriminately and rather carelessly from previous publications. Much useful information is included, but a work of such scope appears to have been overambitious.—C. C. LINDSEY, *Institute of Fisheries, University of British Columbia, Vancouver, B. C.*

TERRARIENKUNDE. 3.THEIL ECHSEN. 1957. 264 pp., 4 col. pl., 216 figs., cardboard (DM 24.50 $6.13); 4. TEIL SCHLANGEN, SCHILDKRÖTEN, PANZERECHSEN REPTILIENZUCHT UND AUFÜRLICHES SACREGISTER. 1959. 379 pp., 6 col. pl., 276 figs., cardboard (DM 32.—=$8.00). By Wilhelm Klingelhöffer. Second, completely revised edition issued by Christoph Scherpner. Alfred Kernen Verlag, Stuttgart.—These are the last parts of this terrarium handbook. Comments on the earlier sections (*Copeia*, 1957, no. 4, p. 314; 1958, no. 3, p. 63) apply here as well. The general discussions of lizards and snakes should be read with caution. The parochial treatment of the literature, omission of several major groups of animals and the spectacular price may well be deplored. Nevertheless a useful source if used with discrimination.

TEXTBOOK OF COMPARATIVE HISTOLOGY. By Warren Andrew. Oxford University Press (New York), 1959, xix 652 pp., 3 col. pls., 220 black and white. $15.—.—An attempt at a complete comparative histology ranging from Protozoa to Mammalia. The somewhat phantastic price, stylistic peculiarities and many factual lapses (some possibly due to the fact that this is the first edition of a most ambitious undertaking) are serious drawbacks. The illustrations are adequate at best. Never-the-less this is the only

genuinely comparative textbook available, and as such deserves serious consideration.

MEMOIRS ON INDIAN ANIMAL TYPES. I. DASYATIS (THE STING RAY). M. Chandy. Maxwell Co. Private Ltd., Lucknow, India. 1957. ix + 123 pp. 62 figs. Rs. 5.—The bulk of this book (103 pages) consists of a moderately detailed description of the anatomy of the Indian species of *Dasyatis*, especially *D. imbricata* and *D. uarnak*. There is also a brief taxonomic introduction and, at the end, a few notes on the natural history, the economic importance, and directions for the dissection of this genus; however these parts are all incidential, and the value of the volume consists wholly in the anatomical descriptions.

Since the reviewer has not tried to dissect a specimen of *Dasyatis* using this book, little can be said concerning these descriptions. They appear to be quite detailed in most respects although the branchial muscles and spinal nerves are treated very briefly and the lymphatics are, as far as I can tell, not mentioned at all (checking on such a point is difficult as there is no index). There are numerous figures, including many of sections through the entire animal, which, although not exceptional, are quite clear and usable.

The most serious criticisms of the work concern its organization and production. Like the lack of an index, the bibliography leaves much to be desired. While many of the works cited are listed at the end of the book, others are cited only in footnotes and some are mentioned without any citation. The bibliography, which is not extensive, is further plagued by an excessive number of typographical errors. Finally the cardboard used for the covers shows, on my copy at least, a marked tendency to come apart, and the binding is rather weak.

Despite these criticisms this volume is, to my knowledge, the only one entirely devoted to a reasonably detailed and illustrated anatomy of a ray and is, therefore, useful to anybody working with these animals or interested in comparative anatomy in general. Unfortunately the binding, bibliography, and index raise problems and will make many workers prefer to continue using Daniel's *The Elasmobranch Fishes*. Nevertheless, this book should be a useful addition to the literature on elasmobranch anatomy, and Professor Bhatia is to be congratulated on reviving the *Indian Zoological Memoirs* under a new title and on this, the first memoir of the new series.

FUNDAMENTALS OF ECOLOGY. By Eugene P. Odum and Howard T. Odum. W. B. Saunders Co., Philadelphia, Pa. 1959. 546 pp., 160 figs. $7.50. A revision of the well known textbook.

THE MOLECULAR BASIS OF EVOLUTION. By Christian B. Antinsen. John Wiley & Sons, Inc., New York. 1959. 228 pp., 99 figures. $7.00.—A summary for the non-expert of the most recent information about evolution at the chemical level—especially refreshing to the non-expert in three aspects (1) that no current theory is treated as gospel; (2) that the explanation is both lucid and moderately full; (3) that there is an explicit attempt to portray this topic as part of a larger field which includes morphological and genetical evolutionary theory. Many tables and well selected figures. Chapter bibliographies.

EDITORIAL NOTES AND NEWS

Annual Meeting

THE 40th annual meeting of the American Society of Ichthyologists and Herpetologists will be held in Chicago June 17–19, 1960, at the Chicago Natural History Museum. Hotel headquarters will be the Conrad Hilton Hotel, which is only a ten-minute walk away from the museum. The Board of Governors will hold its meeting at the hotel at 8:00 p.m., June 16.

Requests for time on the program must be received by the program chairman, Dr. George B. Rabb, Chicago Zoological Society, Brookfield, Illinois, not later than May 1. Please submit name(s) of author(s), title of paper, time required for presentation, projection equipment needed, and any other special requirements.

Requests concerning other aspects of meetings should be addressed to the chairman of the local committee, Dr. Robert F. Inger, Chicago Natural History Museum, Chicago 5, Illinois.

Sale of Check lists

ASIH Publications Secretary, Dr. N. Bayard Green, reports that nearly 200 copies of the 6th edition of *A Check List of North American Amphibians and Reptiles* (by the

late Karl P. Schmidt) have been sold since the price was reduced from $3.25. Members of ASIH and subscribers to *Copeia* may now purchase copies for $1.50 each. Orders, accompanied by check or money order, should be sent to Dr. N. Bayard Green, Dept. Zoology, Marshall College, Huntington 1, W. Va. Many members have bought extra copies for various purposes—to have one at home for ready reference, to send to colleagues in other countries, to give to young people who are showing a developing interest in herpetology, etc.

N.S.F. THE Division of Biological and Medical Sciences of the National Science Foundation announces that the next closing date for receipt of basic research proposals in the Life Sciences is May 15, 1960. Proposals received prior to that date will be reviewed at the summer meetings of the Foundation's advisory panels and disposition will be made approximately four months following the closing date. Inquiries should be addressed, to the National Science Foundation, Washington 25, D. C.

The University of Texas DR. W. FRANK BLAIR is continuing his research on isolating mechanisms and speciation in anuran amphibians with support from the National Science Foundation and on the effects of x-irradiation on a natural population of *Bufo valliceps* with support from the Atomic Energy Commission. His population study of *Sceloporus olivaceus* is due for publication by the University of Texas Press in December, 1959, under the title, "The Rusty Lizard, a Population Study."

DR. H. SZARSKI of Copernicus University, Poland, was a November visitor. He is collecting material for comparative anatomical studies of amphibian circulation.

M. J. FOUQUETTE completed the Ph.D. in August and is now an assistant professor of biology at the University of Florida. The title of his dissertation was, "Isolating mechanisms in three sympatric species of tree frogs, genus *Hyla*, in the Canal Zone." TED C. MICHAUD also completed the Ph.D. degree in August and is now at Carroll College, Wisconsin. The title of his doctoral dissertation was, "Vocal variation in *Pseudacris clarki* and *Pseudacris nigrita* in Texas."

Doctoral students and their research problems in herpetology include: DON HUNSAKER, "Isolating mechanisms in the *Sceloporus torquatus* group," who expects to complete the degree in June, 1960; CLIFFORD JOHNSON, "Relations in the *Hyla versicolor* complex"; HAROLD LOUGHLIN, "Interspecific relations of some natural populations of lizards"; WAYNE MCALISTER, "Geographic variation and speciation in *Rana pipiens* in Texas"; RAY PORTER, "Relations in the *Bufo valliceps* group of toads."

E. A. DELCO, JR., a Ph.D. candidate, is continuing his studies on the comparison of *Notropis lutrensis* and *venustus*, with emphasis on ethological isolating mechanisms. He is also working on similar problems in *Gambusia*. G. E. DREWRY is finishing his MA studies on temperature tolerance in *Gambusia affinis*. He has initiated a study of hybridization in *Fundulus* as a part of his Ph.D. program. He is emphasizing hybrid fertility and cytomorphology. He is also studying the cytomorphology of *Mollienesia* in an effort to resolve the *M. formosa* problem. MRS. M. V. JOHNSON is working on the comparative embryology of darters for a MA degree. J. L. TILTON is finishing his studies on the fish fauna of the lowor Colorado River, Texas, for a MA degree. DR. CLARK HUBBS is continuing his studies on hybridization as an index to phylogeny and isolating mechanisms under National Science Foundation support.

L. R. Richardson DR. L. R. Richardson, of Victoria University, New Zealand, has recently received two honors. He was elected a Fellow of the Royal Society of New Zealand and was also awarded the Hutton Medal of the Royal Society of New Zealand for his researches on the zoology of Cook Straight. This was the twelfth award of the medal which is given every third year for research in New Zealand botany, geology, or zoology. This was the first occasion in the history of the Society when a fellowship and senior research award had been made at the same time to one person.

Foreign Visitors MEMBERS of the society traveling in the United States following the First International Oceanographic Conference this fall include: DR. N. B. MARSHALL of the British Museum who is currently working on the Macrouides of Western North America; DR. G. S. CARTER of Cambridge University, continuing his work on the Adaptations of Fishes; DR. ERIC DENTON, Plymouth Laboratory, studying buoyancy in deep sea fishes and DR. A. M. OLSEN, C.S.I.R.O., Division Fish and Oceanography, Hobart, Tasmania who is continuing his studies on sharks.

University of Florida

A NUMBER of changes have occurred since news of herpetological and ichthyological activities in the Florida State Museum and Department of Biology were last reported to readers of Copeia. Among the graduate students, WAYNE KING is completing a systematic review of the *Sphaerodactylus* of the Lesser Antilles. He expects to continue at this institution for the doctoral degree. GARNETT BROOKS, JR. has just joined our group and has yet to decide on the details of his herpetological research. In the doctoral program are DANIEL BELKIN studying the respiratory adaptations for prolonged submergence in *Sternothaerus*, HAROLD HIRTH comparing the population ecologies of *Ameiva* and *Basiliscus* in Costa Rica, DOUGLAS ROSSMAN studying geographic variation in *Thamnophis sauritus*, and ROBERT MOUNT working on the biology and systematics of *Eumeces egregius*, CRAWFORD JACKSON undertaking a new problem shortly having just completed a study of the comparative osteology of *Deirochelys*, *Chrysemys*, and *Emydoidea*, ALAN HOLMAN continuing his studies of North American paleoherpetofaunas, and RAM SETHI now finishing his work on the phylogeny and evolutionary trends in oviparous cyprinodonts as revealed by osteology.

Among the staff, ARNOLD GROBMAN, director of the Florida State Museum, and WALTER AUFFENBERG, Assistant Professor of Biological Sciences and formerly in charge of fossils, are both on leave of absence for several years to direct the Biological Sciences Curriculum Study sponsored by the AIBS. They are currently quartered at the University of Colorado, Boulder. ARCHIE CARR was recently named Graduate Research Professor, an honored position in which he may devote full time to his study of the biology of marine turtles. COLEMAN GOIN is engaged in an extensive study of South American hylid frogs in association with DORIS COCHRAN of the National Museum. JOHN KILBY is attempting to explain the genetics of melanism in *Gambusia*. WILLIAM REIMER has returned after a year in Israel as a Fulbright lecturer to reassume his Museum post as curator in herpetology and curator in charge of the Department of Natural Sciences, and to continue a herpetofaunal study of the poorly known Apalachicola basin in western Florida. JACK FOUQUETTE has joined us as Interim Assistant Professor of Biology; his interest continues in the ecology of Central American hylids. In January DONN ROSEN, formerly of the New York Zoological Society, will join the group as Assistant Professor of Biology and Assistant Curator in charge of fishes.

The Bulletin of the Florida State Museum, now in its fifth volume, continues to publish papers of interest to readers of Copeia. A list of available titles may be had by addressing a request to the Curator of Natural Sciences, University of Florida Collections, Flint Hall.

Copeia Mailing Dates, 1959

COPIES of volume 1959 of *Copeia*, mailed first-class to the Editor-in-Chief, were postmarked at Baltimore, Maryland, as follows: No. 1 (dated April 17), April 17; No. 2 (dated July 24), July 24; No. 3 (dated October 9), October 13; and No. 4 (dated December 30), January 12, (1960). The 1960 date should be borne in mind in making references to papers included in the No. 4 issue.

New Editors

THE new editors of COPEIA wish to thank DR. PHILIP SMITH and DR. FRED CAGLE for their previous service as Editors and for their help in the smooth transfer of the offices. We also wish to thank the many members of the society who have offered their services to the present editorial board. We are aware that we are here to serve the society; our plead is that you will inform us of your needs.

There is no backlog of manuscript material for any section of the journal. Manuscripts submitted in the form requested in COPEIA, 1958 (1):67–69 will be published in the minimum time.

The Society-owned set of COPEIA, bound through 1957 and complete to date, which is in custody of the Managing Editor, was turned over to D. L. Jameson during September, 1959.—D.L.J.

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The American Society of Ichthyologists and Herpetologists is a member of the American Institute of Biological Sciences and of the Division of Biology and Agriculture, National Research Council, and is an affiliate of the American Association for the Advancement of Science. An annual contribution is made to the publication of the Zoological Record.

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